4101 F-#75

WADC TECHNICAL REPORT 52-220

ADA075879

TI-4072

STUDIES TO DETERMINE THE ELECTRICAL AND PHYSICAL PROPERTIES OF AIRCRAFT LUBRICATING OILS

WADC
52-220
ATI 187966

Joseph L. Radnik
Armour Research Foundation

September 1952

WRIGHT AIR DEVELOPMENT CENTER

DISCLAIMER NOTICE

REPORT NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

The information furnished herewith is made available for study upon the understanding that the Government's proprietary interests in and relating thereto shall not be impaired. It is desired that the Judge Advocate Office, WCJ, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, be promptly notified of any apparent conflict between the Government's proprietary interests and those of others.

FOREWORD

This report was prepared by the Armour Research Foundation on Purchase Order Number 33(038)-3793, Research and Development Order Number 613-12. Work was initiated in August, 1951, and was administered under the direction of the Petroleum Products Branch of the Materials Laboratory, Directorate of Research, Wright Air Development Center, Mrs. E. J. Bartholomew acting as project engineer.

Personnel of the Armour Research Foundation who participated in this project are Clifford C. Petersen, Supervisor, Materials and Measurements, Joseph L. Radnik, Paul E. Bowers and Richard Purcell of the Electrical Engineering Department; Maurice Kayner, Chief Analytical Chemist, Ralph Hinch, Jr., Donald Laskowski, Donald O. Landon, and Ilse M. Wolfson of the Chemistry and Chemical Engineering Department.

WADC TECHNICAL REPORT 52-220

STUDIES TO DETERMINE THE ELECTRICAL AND PHYSICAL PROPERTIES OF AIRCRAFT LUBRICATING OILS

Joseph L. Radnik
Armour Research Foundation
Illinois Institute of Technology

September 1952

Materials Laboratory
Contract No. AF 33(038)-3793
RDO No. R613-12

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

ABSTRACT

To assist in evaluating the capacitance type fuel quantity gage for use with oils, a study was made of various grades of aircraft lubricating oils by the Armour Research Foundation, Chicago, Illinois.

Measurements of dielectric constant, dissipation factor, and density were made on 144 new and used specimens of aircraft lubricating oils of grades 1100, 1080, 1065, 1010 and 1005 under the influence of changing frequency and temperature. Special studies were made to determine the effects of dilution with aviation fuel, the effect of additive compounds, and the effect of oil clinging to the sides of the sensing element of the gage.

Used oil specimens were found to have substantially higher dielectric constants and dissipation factors than the corresponding new oil specimens. Dissipation factors as high as 5.020 were detected in some used specimens. Addition of various additive compounds to a base oil produced a significant change in the dielectric properties of the mixture.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDING GENERAL:

M. E. SORTE
Colonel, USAF
Chief, Materials Laboratory
Directorate of Research

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

LIST OF FIGURES (Cont'd)

LIST OF TABLES

LIST OF TABLES (Cont'd)

LIST OF TABLES (Cont'd)

are cut off. No change in cell temperature was detected due to this brief opening.

Periodic calibrations of the measuring cells were made with chemically pure benzene. Corrections of the guarded Balsbaugh cell in all cases have been negligible.

B. Density Measurements

Oil density was determined using special pycnometers calibrated to indicate true volume. This method, described in A.S.T.M. Specification D-941-57T, gives results which are accurate to within 0.05 percent. Constant temperature liquid baths were constructed using transparent Dewar flasks so the pycnometer graduations may be read without lifting the pycnometer out of the bath. At temperatures above 130°F(54°C) actual measurements with the special pycnometer method were impossible to obtain; hence, the values of density above 130°F(54°C) were extrapolated. The density in grams per cc was converted to density in pounds per gallon by multiplying by 8.3454.

C. Capacity Index

The capacity index is defined in OSRD Report No. 4016, June 30, 1944, "Some Characteristics of Aircraft Engine Fuels: Their Influence on Capacitor Type Tank Gages," as being the ratio

$$\frac{K - 1}{D}$$

where K is the dielectric constant of the liquid and D the liquid density.

The OSRD report shows that the indication of the capacitance type gage is proportional to the product of the mass and the capacity index provided the liquid in the tank has constant surface area.

D. Identification of Specimens

To distinguish between the various specimens, a code was devised which identifies the type and the source of each specimen. This code appears after each specimen number and is defined in the following manner:

Description	Code
New Oils from refineries	
As received	NR
10% dilution	10D
20% dilution	20D
30% dilution	30D
New Oils from Air Force bases	NA
Used Oils from Air Force bases	UA
Used Oils direct from Aircraft	UB
Effect of Additives	S

The oils from the Air Force bases were normally received in pair samples, that is, one gallon of new oil and one gallon of the same grade after use.

The classification, "Used Oils Direct from Aircraft," refers to used oil which was taken directly from a specific type of aircraft for various engine and oil times.

E. Effect of Dilution

Each specimen of new oil received from refineries and re-refineries was diluted with 10, 20, and 30% by volume of the total mixture of the same sample of grade 100/130 aviation fuel (Specimen No. 393 of the fuel study). Each of these diluted portions was treated as a separate specimen and tests were made under the same conditions as for the original specimens.

F. Effect of Additive Compounds

The effect of additive compounds was determined by blending various compounds with a grade 1100 base oil and investigating the dielectric properties of the base oil and each mixture.

G. Effect of Oil Clinging to Sides of Gage

Because of the small effects which were expected, the experimental cell developed under the fuel portion of this project was used for measurements of changes in capacitance due to oil clinging to the sides of the cell. An analytical study was also made for the purpose of correlation with experimental data.

SECTION IV

RESULTS

A. Dielectric Constant, Density, Capacity Index, and Dissipation Factor versus Temperature

Dielectric constant at 400 cps and density were measured and capacity index was calculated for 57 specimens of new, used, and diluted oils over the temperature range of -65°F(-54°C) to 200°F(93°C). The results of these measurements are presented in Tables 1 to 10 inclusive and are shown graphically in Figures 1 to 16 inclusive. To prevent damage to the measuring cells, measurements were not normally made at temperatures below that at which solidification occurred. At temperatures above 130°F(54°C), the diluted oil mixtures emit vapors which in the closed temperature cabinet were considered hazardous. To obtain measurements on these specimens at 185°F (85°C), the mixtures were first distilled at 185°F(85°C) in an open chamber.

The mean slopes of the dielectric constant versus temperature curves were calculated for each grade of new, diluted and used oil to be used in determining the mean temperature coefficient of dielectric constant and are presented in

Tables 24 to 28 inclusive.

The electrical measuring circuit, using the Balsbaugh cell is sensitive only to values of dissipation factor greater than about 0.0007 at 400 cps. Therefore, only dissipation factors exceeding that value are presented in Tables 12 and 13. Figures 17 to 21 show dissipation factor versus temperature for each pair of new and used oils tested over the range -40°F(-40°C) to 200°F(93°C).

The density of all specimens was practically a linear function of temperature. Data has been complied to show this relation and is presented in a subsequent section.

B. Dielectric Constant, Density, Capacity Index, and Dissipation Factor at 185°F(85°C), 400 Cps.

The dielectric constant, dissipation factor and density were measured and the capacity index calculated for all specimens of new and used oil at 185°F(85°C) and 400 cps. These results are presented in Tables 14 to 17, inclusive. Figures 22 to 27 show dielectric constant, density, and capacity index versus specimen number (in order of decreasing dielectric constant) for all new and used oils.

Figures 28 and 29 present plots of dielectric constant versus density at 185°F(85°C) for each used oil tested. Since the grade identification of the UB specimens was unavailable, the used oils direct from aircraft were treated as a separate group.

To facilitate comparison, the results of measurements at 185°F(85°C) and 400 cps on all sets of pair samples are presented in Table 18. Figures 30 to 34 show plots of dielectric constant and capacity index versus density at 185°F(85°C) for each pair of new and used oils.

Tables 19 and 20 present the mean values of dielectric constant, density, and capacity index at 185°F(85°C) for each grade of new and used oil.

C. Slope of Density versus Temperature Curves as a Function of Density

The density versus temperature curves of 39 new, 32 used, and 30 diluted oil specimens were analyzed and equations were derived which predict density values at various temperatures.

Tables 21, 22, and 23 give the slopes of the density versus temperature characteristics for new, used and diluted oils respectively. Figures 35, 36, and 37 present plots of slope versus density and lines of regression, determined by statistical means ("Methods of Correlation Analysis", M. Ezekiel, Wiley and Sons, 1941, Chapter 8). These lines are the best straight lines which can be drawn to depict the correlation between two variables. The figures also give the per unit correlation, unity being perfect correlation.

Based on these calculations, the general equation for determining the density of new oils at temperature T when the density at 185°F is known

becomes

$$D_T = D_{185}\,(.905476 + .00051094T) - .0065756T + 1.216490$$

where D is the density in pounds per gallon, and T is the temperature in degrees F. Equations which apply to specific temperatures are

$$D_{-4} = D_{185}\,(.903432) + 1.242792$$

$$D_{32} = D_{185}\,(.921826) + 1.006071$$

$$D_{77} = D_{185}\,(.944818) + 0.710169$$

For used oil when the density at 185°F is known, the general equation becomes

$$D_T = D_{185}\,(.930902 + .00037350T) - .0056561T + 1.046377$$

where D is the density in pounds per gallon, and T is the temperature in degrees F. Specific equations are

$$D_{-4} = D_{185}\,(.929408) + 1.069001$$

$$D_{32} = D_{185}\,(.942854) + 0.865382$$

$$D_{77} = D_{185}\,(.959662) + 0.610857$$

For all diluted oils when the density at 77°F is known, the general equation for determining density at temperature T becomes

$$D_T = D_{77}\,(.982592 + .00022608T) - .00471943T + 0.363396$$

where D is the density in pounds per gallon, and T is the temperature in degrees F. Specific equations are

$$D_{-4} = D_{77}\,(.981688) + .382174$$

$$D_{32} = D_{77}\,(.989827) + .212374$$

$$D_{185} = D_{77}\,(1.024417) - .509699$$

D. Dielectric Constant, Density, and Capacity Index at -4°F(-20°C), 77°F(25°C), and 185°F(85°C)

The mean temperature coefficients of dielectric constant for each grade of new, used, and diluted oils were determined from the mean slopes of the dielectric constant versus temperature curves and the mean values of dielectric constant, and are presented in Tables 24 to 28 inclusive. The temperature coefficient is defined by the following equations:

$$K_t = K_{REF}\left[1 - \alpha(t - T_{REF})\right] \quad \text{or} \quad K_t' = K_{REF'}\left[1 - \alpha'(t - T_{REF'})\right]$$

where

K	is the dielectric constant
t	is the temperature in degrees F
t'	is the temperature in degrees C
T_{REF}	is the reference temperature in degrees F
$T_{REF'}$	is the reference temperature in degrees C
α	is the temperature coefficient of dielectric constant per degree F
α'	is the temperature coefficient of dielectric constant per degree C.

Using these equations, the dielectric constants of all new oils not tested at temperatures other than 185°F(85°C) were calculated at -4°F(-20°C) and 77°F(25°C). Densities at these two temperatures were determined by means of the equations of the preceding section, thereby permitting calculation of capacity index.

Tables 29 and 30 present the dielectric constant and density and Tables 31 and 32 the capacity index of all new oils specimens at -4°F(-20°C), 77°F(25°C), and 185°F(85°C).

Figures 38 and 43 present plots of dielectric constant versus density at the three temperatures along with lines of regression for these two variables. Figure 44 shows the relationship existing between the lines of regression of the various grades of oil tested. Figure 45 to 50 show plots of capacity index versus dielectric constant at the three temperatures for all new oil specimens.

E. Dielectric Constant at 400 Cps and 200 KC at 185°F(85°C)

The dielectric constant of each specimen of new and used oil was measured at 200 KC as a spot check on the effect of frequency upon dielectric constant. Tables 33 to 36 present the dielectric constant at 400 cps and 200 KC for all new and used oil specimens.

F. Dielectric Constant Versus Frequency at 185°F(85°C)

Twenty-one specimens of new and used oil were tested over a complete frequency range of 400 cps to 200 KC at 185°F(85°C). The results of these measurements are presented in Tables 37 to 40 and shown graphically in Figures 51 to 61, inclusive.

G. Effect of Dilution

The dielectric constant, density, and capacity index at 77°F(25°C) of all the diluted new oil specimens are presented in Tables 41, 42, and 43.

Tables 44 to 47 present the mean values of dielectric constant, density, and capacity index for each grade of undiluted and diluted oil at 77°F(25°C). The mean values of the undiluted oils were taken from the calculated data of section D.

The results of spot checks at 200 KC on the diluted specimens at 77°F (25°C) are presented in Tables 48, 49, and 50.

Fourteen specimens of diluted oil were tested over a complete frequency range of 400 cps to 200 KC at 77°F(25°C). The results of these measurements are presented in Tables 51 and 52, and are shown graphically in Figures 62, 63, and 64.

H. Effect of Additive Compounds

To determine the effect of additives upon the dielectric properties of oils, various compounds furnished by the Air Force were blended with grade 1100 base oil. The results of measurements upon the base oil and the blended mixtures are presented in Tables 53 to 57.

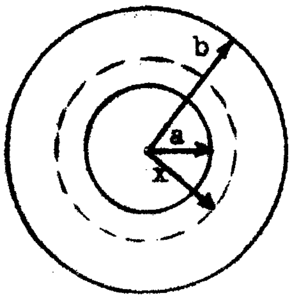
Figure 65 presents a plot of dielectric constant versus density at 77°F(25°C) for the effect of additive specimens. Figure 66 shows a plot of dielectric constant versus frequency for four effect of additive specimens.

J. Effect of Oil Clinging to Sides of Gage

The experimental cell developed under the fuel portion of this project was used to obtain experimental data upon the effect of oil clinging to the sides of the gage. The empty cell capacitance was measured at 130°F(54°C) and the cell was completely filled with the oil to be tested. After the oil was allowed to drain until no further droplets were visible at the drain plug, the cell capacitance was remeasured. The following results were obtained:

Grade	Empty Capacitance uuf	Drained Capacitance uuf	Increase uuf	% Change
1100	144.26	144.80	0.54	0.37
1080	146.72	149.00	2.28	1.55
1065	148.32	150.40	2.08	1.40
1010	144.76	145.04	0.28	0.19

For the purpose of correlation with experimental data, the following analytical study was made. Consider a capacitor made up of two concentric cylinders of radii a and b.



In the rationalized mks system, the electric flux density at a distance x from the center is

$$D_x = \frac{\sigma}{2\pi x}$$

where D_x is the flux density, σ is the charge per unit length, and x the distance from the center. The electric field intensity, $\mathcal{E}_x$, at the distance x is

$$\mathcal{E}_x = \frac{D_x}{\epsilon_o K} = \frac{\sigma}{2\pi\epsilon_o K x}$$

where ϵ_o is the permittivity of free space $\left[\frac{1}{(36\pi \times 10^9)}\right.$ in rationalized mks units$\left.\right]$, and K is the dielectric constant of the material between the plates. For air, K=1.

The potential difference between the plates in terms of charge per unit length is

$$V_c = \int_a^b \mathcal{E}_x dx = \frac{\sigma}{2\pi\epsilon_o K}\int_a^b \frac{dx}{x} = \frac{\sigma}{2\pi\epsilon_o K} \ln\frac{b}{a}$$

Since the capacitance is defined as the ratio of charge to potential difference, the capacitance per unit length of the cylindrical arrangement is

$$C_{pul} = \frac{\sigma}{V_c} = \frac{2\pi\epsilon_o K}{\ln\frac{b}{a}} \qquad (1)$$

Now consider the same cyclindrical arrangement when each plate is covered by a uniform oil film of dielectric constant K and thickness δ. The capacitance per unit length under these conditions is

$$C_T = \frac{2\pi\epsilon_o K}{\ln\left(\frac{a+\delta}{a}\right) + K\ln\left(\frac{b-\delta}{a+\delta}\right) + \ln\left(\frac{b}{b-\delta}\right)}$$

Therefore, the difference in capacitance per unit length becomes

$$\Delta C = \frac{2\pi\epsilon_o K}{\ln\left(\frac{a+\delta}{a}\right) + K\ln\left(\frac{b-\delta}{a+\delta}\right) + \ln\left(\frac{b}{b-\delta}\right)} - \frac{2\pi\epsilon_o K}{\ln\frac{b}{a}}$$

This difference was evaluated for several different values of oil film thickness and dielectric constant using the physical dimensions of the experimental cell (a=.07422, b=.07779, l=.1238 meter), and the curves shown in Fig. 67 were drawn. This figure indicates the maximum oil film thickness at 130°F(54°C) obtained in the experimental work was approximately 0.05 millimeters for grade 1080 oil.

SECTION V

DISCUSSION

A. <u>Dielectric Constant, Density, Capacity Index, and Dissipation Factor versus Temperature</u>

The dielectric constant of aircraft lubricating oil is practically a linear function of temperature. Particular curves of dielectric constant versus temperature show apparent variations of slope between successive temperature points, but no significance is attached because these variations are about equal in magnitude to the sensitivity of the measuring circuit.

The mean slopes of the dielectric constant versus temperature curves for all grades of used oils excepting grade 1080 were less than the corresponding slopes for the new oils. The maximum change in the mean slope between new and used oil was a 34.1% decrease for grade 1010. The mean slopes of the diluted oil curves generally increase above the new oil slopes for dilutions up to 20% and then decrease slightly for 30% dilution.

Figures 1 to 6 show that as the high temperatures are approached, the dielectric constant of the diluted specimens approaches the value for the undiluted oil. This is due to the evaporation at high temperatures of some of the aviation fuel contained in the diluted specimens.

The density of all specimens was found to be practically a linear function of temperature in the region -65°F(-54°C) to 200°F(93°C). In general, an increase in temperature causes a small decrease in capacity index although many irregularities were noted. Some exceptions may be due to the fact that a small error in dielectric constant causes a relatively large error in capacity index.

As shown in Figures 17 to 21, the dissipation factors of the used oil specimens in particular increase exponentially with an increase in temperature. In going from -4°F(-20°C) to 200°F(93°C), the dissipation factor of grade 1080 specimen, 0-37-UA, increased from 0.0180 to 5.0200, an increase of 278 times.

At any one particular temperature, the dielectric constant of the used specimen of the pair samples is usually larger than the dielectric constant of the new specimen. The dielectric constant of the foreign material in the used oil is probably greater than the dielectric constant of the new oil.

B. <u>Dielectric Constant, Density, Capacity Index, and Dissipation Factor at 185°F(85°C), 400 Cps.</u>

Table 17 indicates that oil drawn from the same aircraft after similar engine or oil times has similar dielectric and physical properties regardless of the engine from which it was drawn. In some cases, the length of engine time had little effect upon the properties of oil taken from one type of aircraft after different engine times.

In Figures 22 to 27, inclusive, new and used oil specimens were arbitrarily arranged in order of decreasing dielectric constant. The plots of density and capacity index do not decrease progressively with decreases in dielectric constant, but a definite trend is evident.

Because of the limited number of UA specimens of each grade received, no definite correlations between dielectric constant and density could be established. It appears, however, that all grades with the exception of hydraulic oil follow a similar pattern. As shown in Figure 29, all UB specimens were treated as a separate group and a definite correlation between dielectric constant and density is apparent.

Table 18 indicates that all used pair samples have substantially larger dissipation factors than the new pair samples. In most cases the same is true for dielectric constant, density, and capacity index. Figures 30 to 34 indicate there is no consistent correlation which exists between dielectric constant and density, and capacity index and density for the pair samples.

Comparison of Tables 19 and 20 indicates the mean dielectric constant is larger for all grades of used oil with the exception of hydraulic oil. A maximum change of 3.5% occurred in grade 1100 oil. The mean density and capacity index were, in general, also larger for the used oil specimens.

C. Slope of Density versus Temperature Curves as a Function of Density

The mean slope of the density versus temperature curves of the used oils was found to be larger than the corresponding slope for the new oils. This means that for a given temperature change, the density of a used oil specimen would change more rapidly than the density of a new oil specimen.

The mean slope of the density versus temperature curves of the diluted oils was 3.32% greater than the mean slope of the undiluted oils. This is probably due to greater change in density that occurs in the aviation fuel contained in the diluted oil mixture.

The use of the density equations derived from the lines of regression yield results which are accurate to within 0.7%.

D. Dielectric Constant, Density, and Capacity Index at -4°F(-20°C), 77°F(25°C), and 185°F(85°C)

With the exception of grade 1080 oil, the mean temperature coefficient of dielectric constant at 185°F(85°C) of the used oil specimens is substantially less than the corresponding coefficient of the new oil specimens. This is due to the smaller slope of dielectric constant versus temperature curves and the larger mean value of dielectric constant at 185°F(85°C) for used oils.

The correlations between dielectric constant and density for new oils at -4°F, 77°F and 185°F, as shown in Figures 38 to 43 are considered to be satisfactory, the highest per unit correlation being .994 for grade 1065 oil. As shown in Figure 44 the slopes of the lines of regression of dielectric

constant versus density of all grades of new oil except hydraulic are very nearly identical. A definite correlation between capacity index and dielectric constant for new oils at the three temperatures is also evident in Figures 45 to 50.

E. Dielectric Constant at 400 Cps and 200 KC at 185°F(85°C)

Comparison of the dielectric constants at 400 cps and 200 KC indicates no appreciable difference although in most cases a very small decrease at 200 KC was detected.

F. Dielectric Constant versus Frequency at 185°F(85°C)

The sensitivity of the measuring circuit using the Balsbaugh cell is approximately 0.2% or slightly over 0.004 in dielectric constant. Considering this sensitivity, the small changes in dielectric constant shown in Figures 51 to 61 are considered to be insignificant.

G. Effect of Dilution

The general effect of dilution, as indicated in Tables 44 to 47, was to decrease dielectric constant and density. This result was generally expected because in most cases the gasoline used for dilution had a lower dielectric constant and density than the new oil. The mean capacity index decreased in going from 10% to 20% dilution and increased in going from 20% to 30% dilution. This indicates that (K-1) decreased more rapidly than D in going from 10% to 20% dilution, and D decreased faster than (K-1) in going from 20% to 30% dilution.

No significant effect upon the dielectric constant of the diluted specimens of varying frequency was detected.

H. Effect of Additive Compounds

Examination of Table 53 shows an appreciable change in dielectric properties is produced by the blending of small amounts of additive compounds with a base oil. The capacity index of the blended mixtures varied from 0.1994 to 0.1606. Specimen 0-59-S had an unusually high dissipation factor of .2450 at 77°F(25°C) and 400 cps.

The effect of varying frequency upon the additive specimens was insignificant. Spot checks on additive specimens at 10°F(-10°C) and 185°F(85°C) indicated behavior which was similar to that of the new and used oils.

Examination of Figure 65 shows a definite correlation exists between dielectric constant and density of the additive specimens.

J. Effect of Oil Clinging to Sides of Gage

The magnitude of change in tank unit capacitance due to oil clinging to the sides of the gage is dependent upon the tank unit size and the thickness of the oil film. A maximum change in the experimental cell capacitance of

1.55% was detected at 130°F(54°C). However, if the actual units have a spacing which is large compared to the 0.070 inch spacing of the experimental cell, the change will be much less significant.

The oil film thickness depends on many factors such as temperature, viscosity, and tank unit surface, and no method is know which will predict the film thickness under specific conditions.

SECTION VI

NOTEBOOKS

Detailed laboratory data are recorded in Armour Research Foundations Notebooks C-1696, C-1698, and C-215.

Respectfully submitted,

ARMOUR RESEARCH FOUNDATION OF
ILLINOIS INSTITUTE OF TECHNOLOGY

J. L. Radnik, Research Fellow

C. C. Petersen, Supervisor
Materials and Measurements

H. J. Finison, Chairman
Electrical Engineering Research

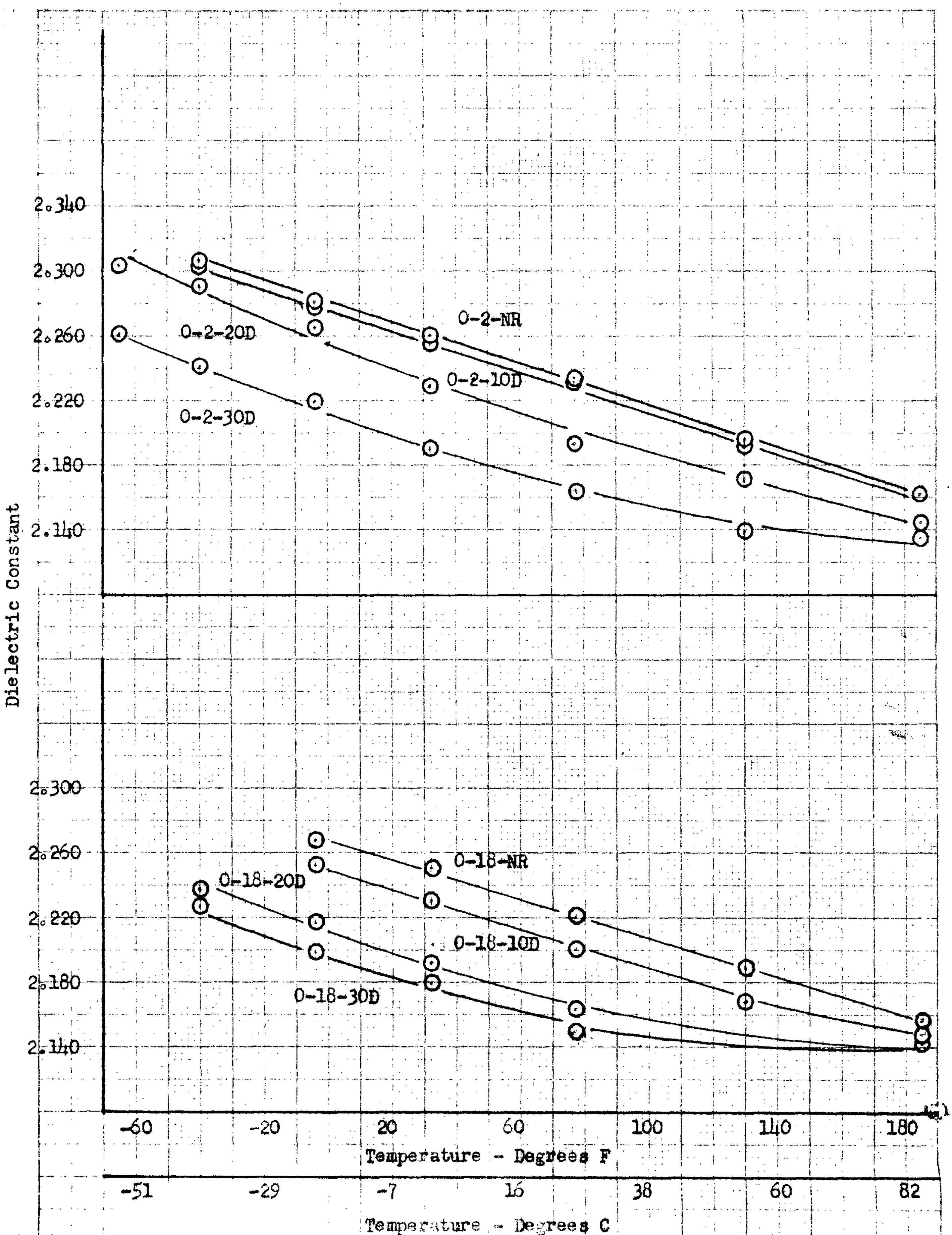


Fig. 1

Dielectric Constant vs. Temperature at 400 cps

Grade 1100 Oil

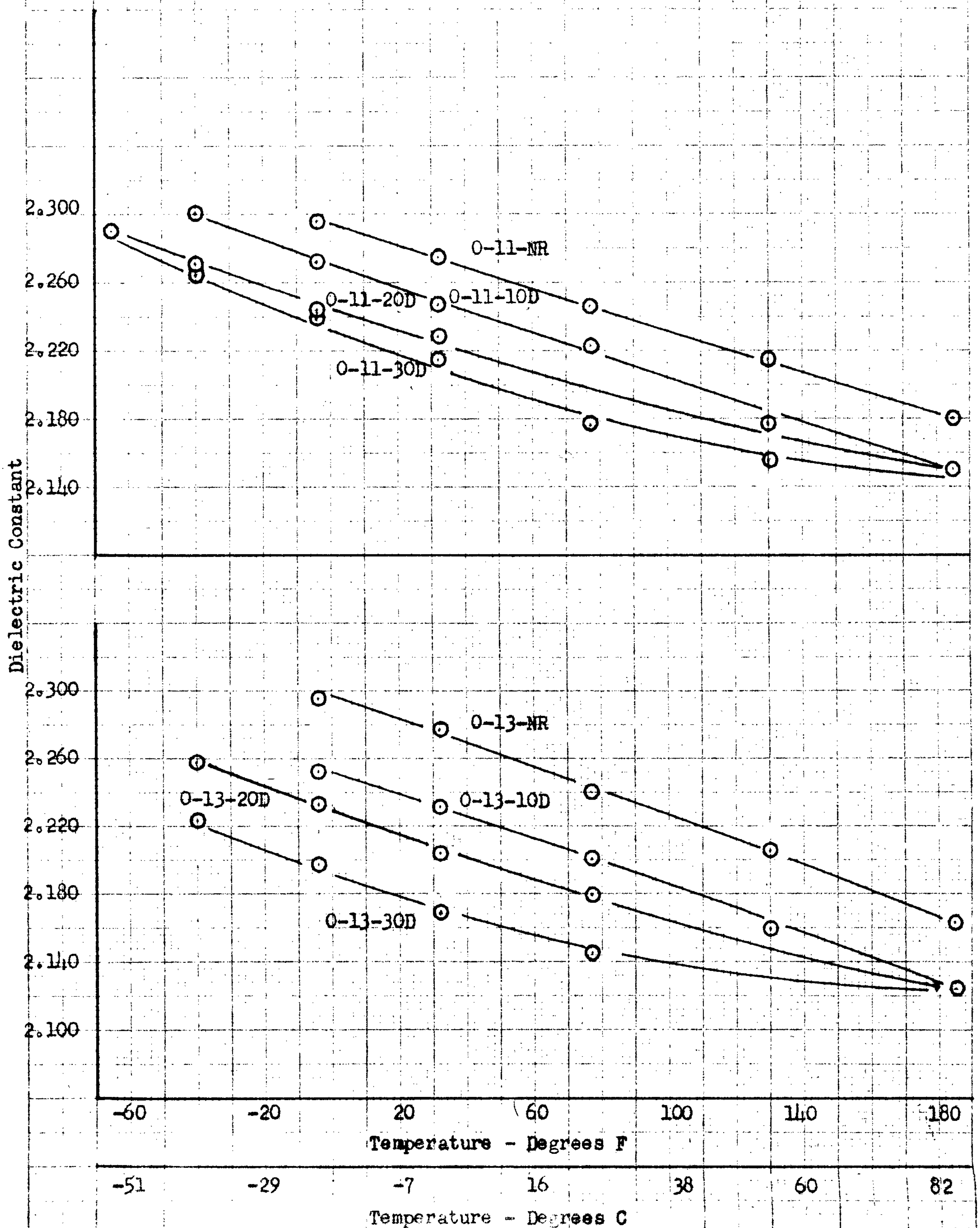


Fig. 2
Dielectric Constant vs. Temperature at 400 cps
Grade 1050 Oil

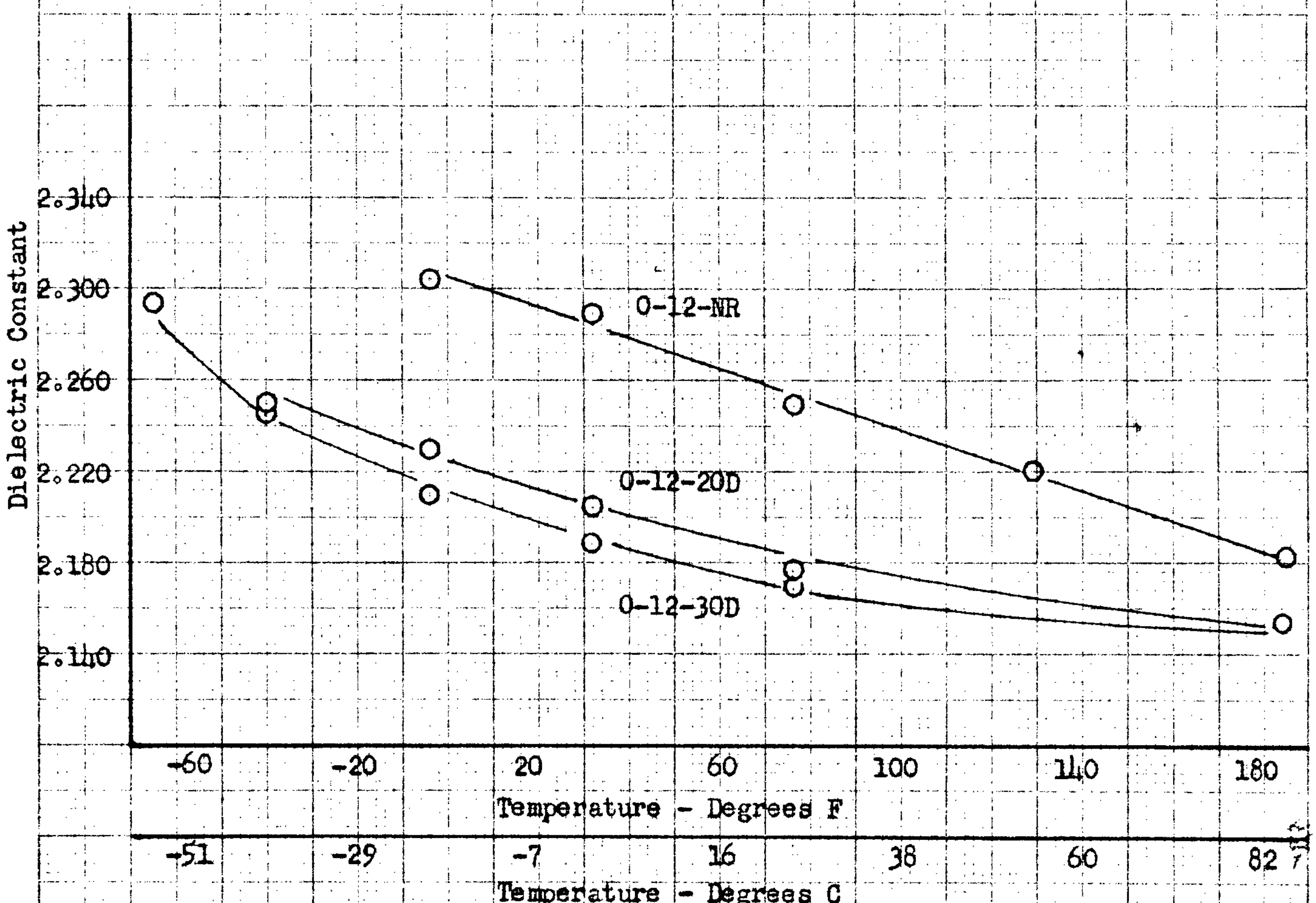


Fig. 3

Dielectric Constant vs. Temperature at 400 cps

Grade 1065 Oil

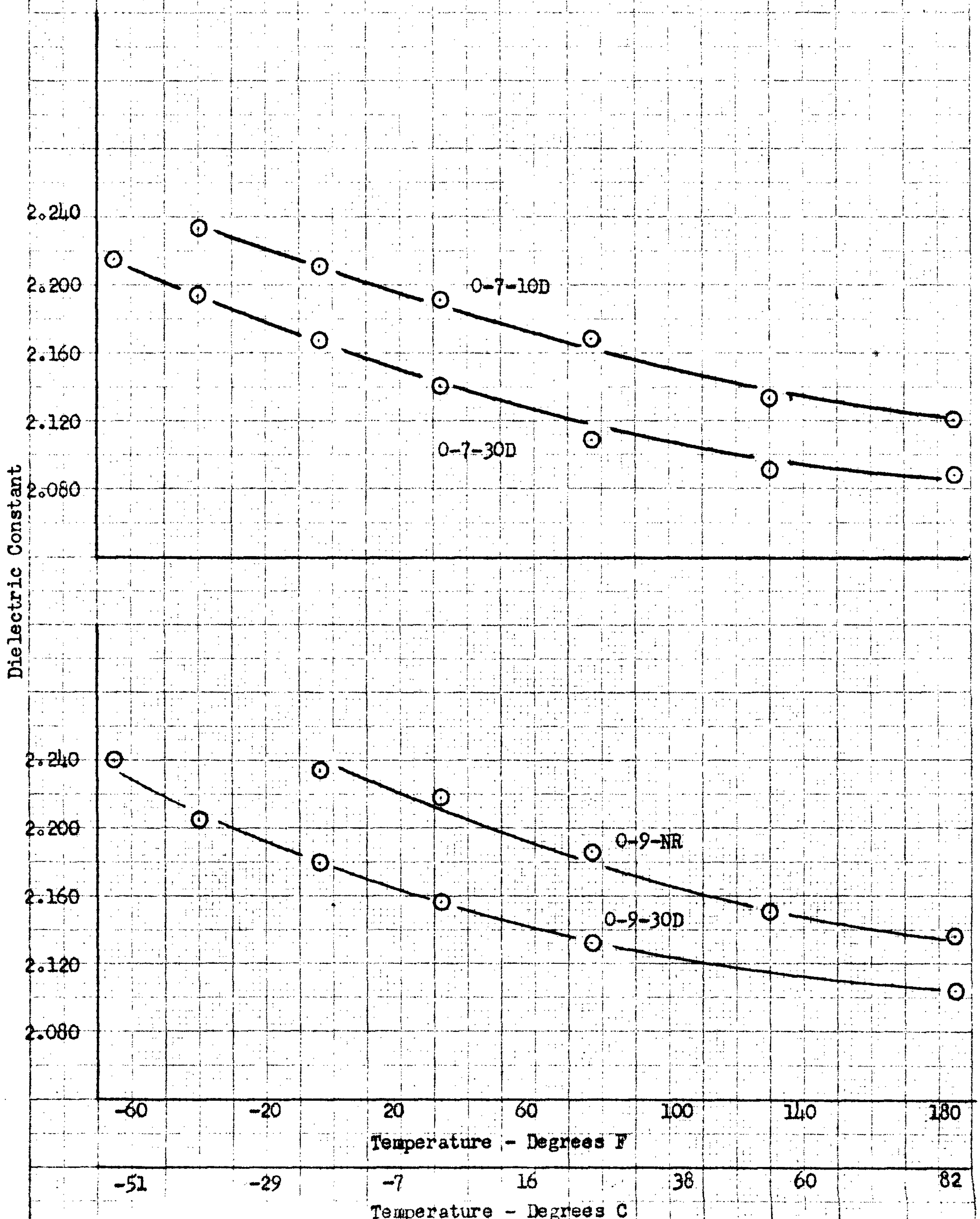


Fig. 4

Dielectric Constant vs. Temperature at 400 cps
Grade 1010 Oil

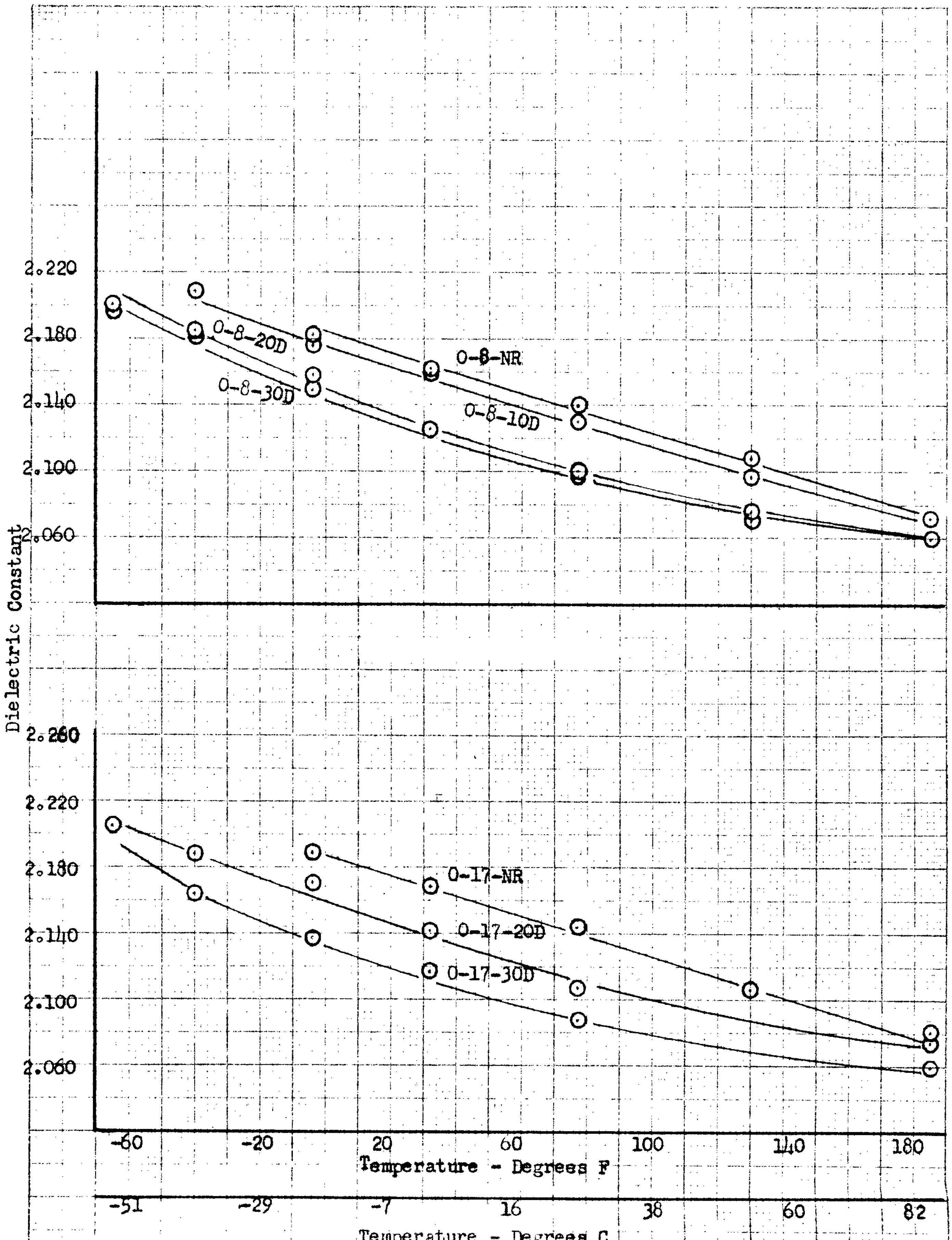


Fig. 5

Dielectric Constant vs. Temperature at 400 cps
Grade 1005 Oil

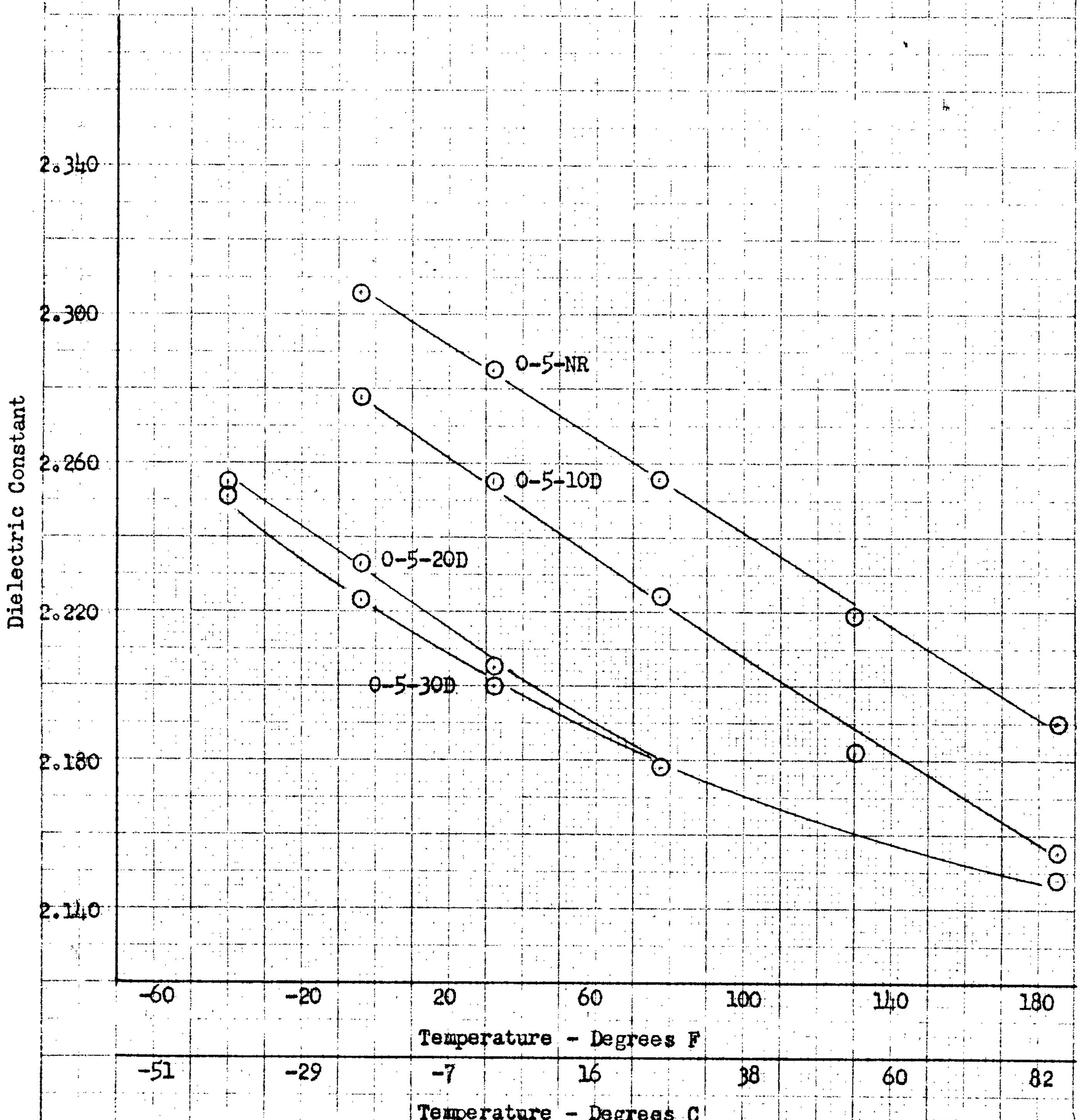


Fig. 6

Dielectric Constant vs. Temperature
Grade 1120 Oil

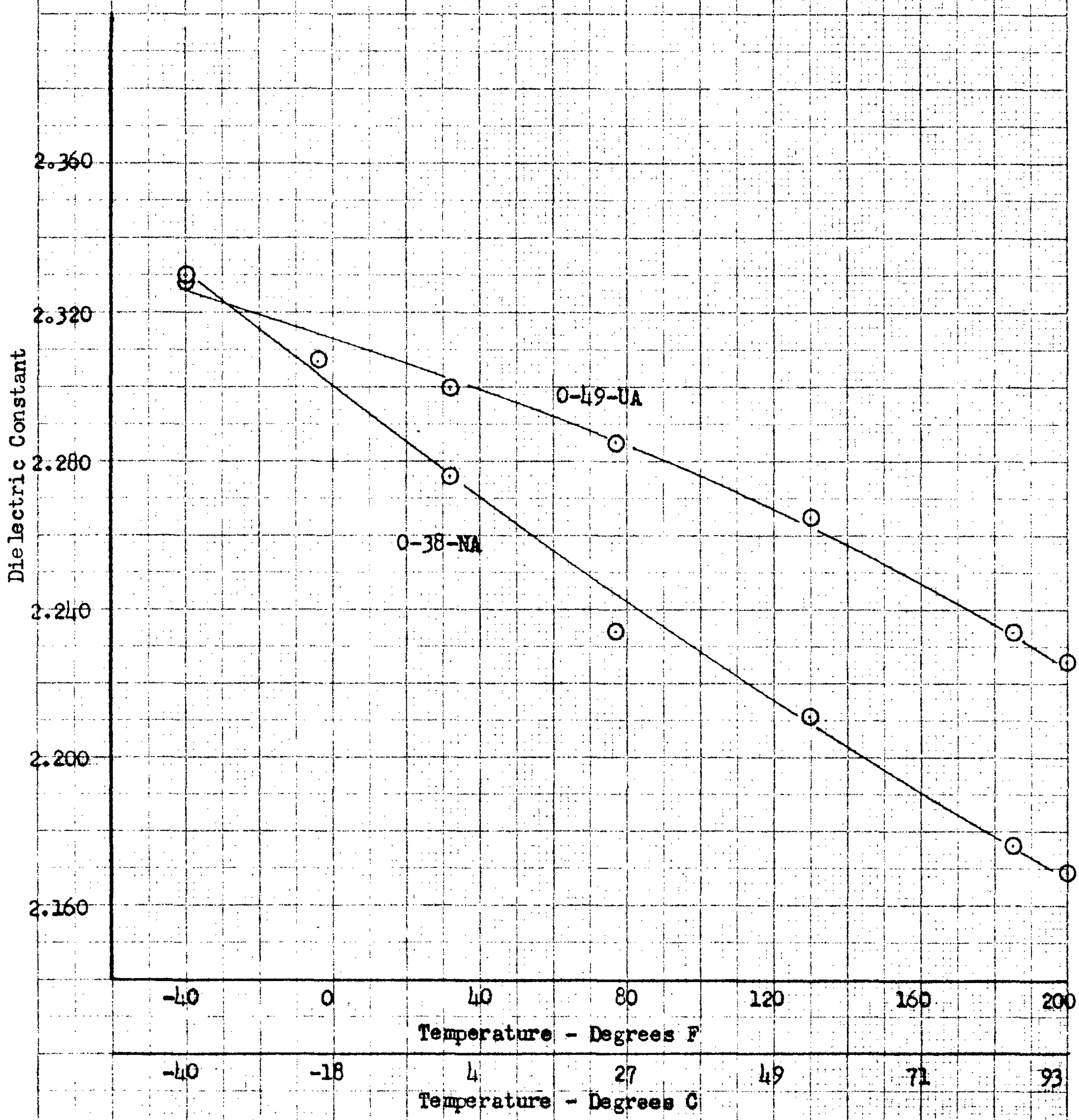


Fig. 7

Dielectric Constant vs. Temperature at 400 cps
Grade 1100 Pair Samples

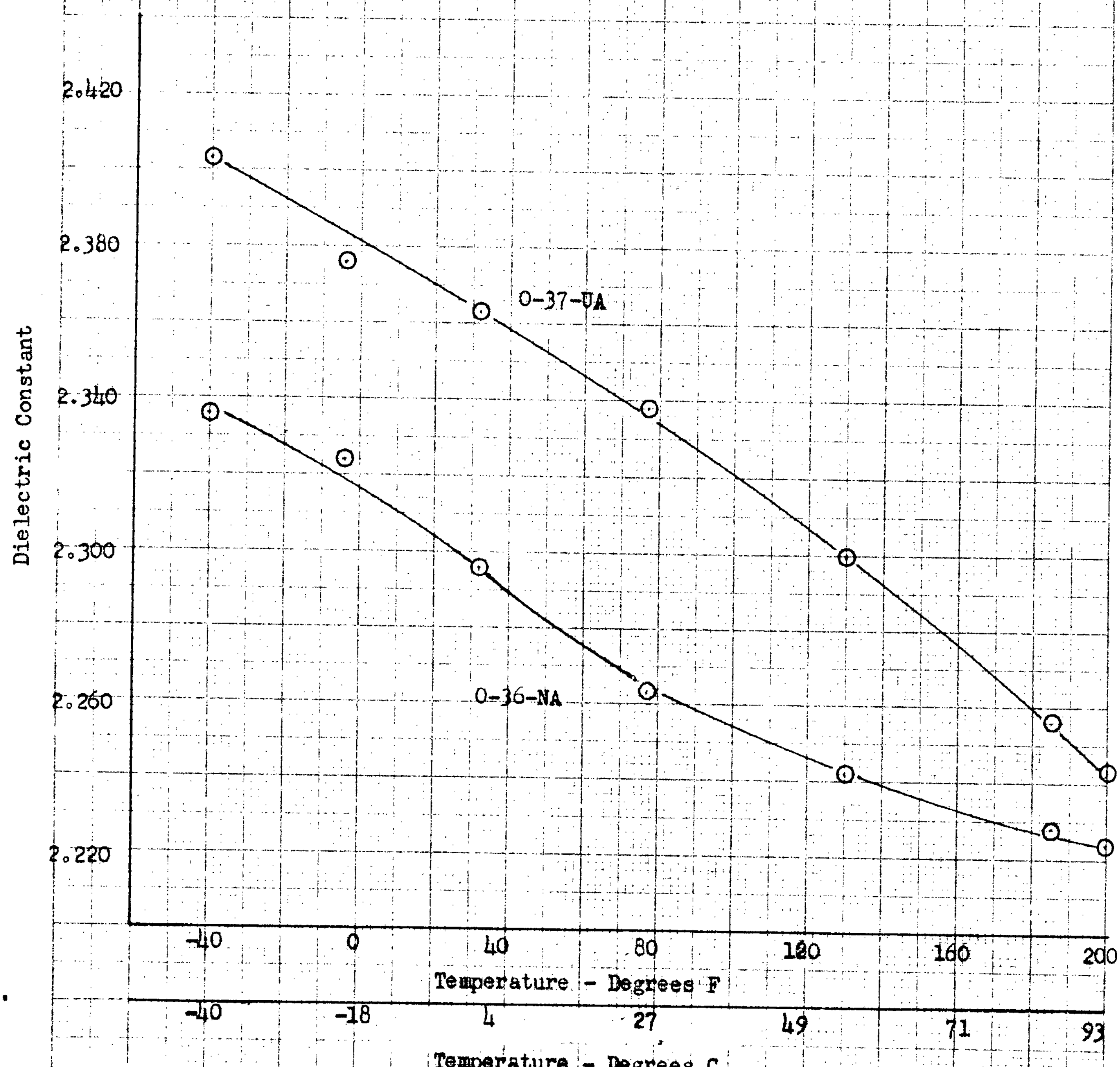


Fig. 8

Dielectric Constant vs. Temperature at 400 cps
Grade 1080 Pair Samples

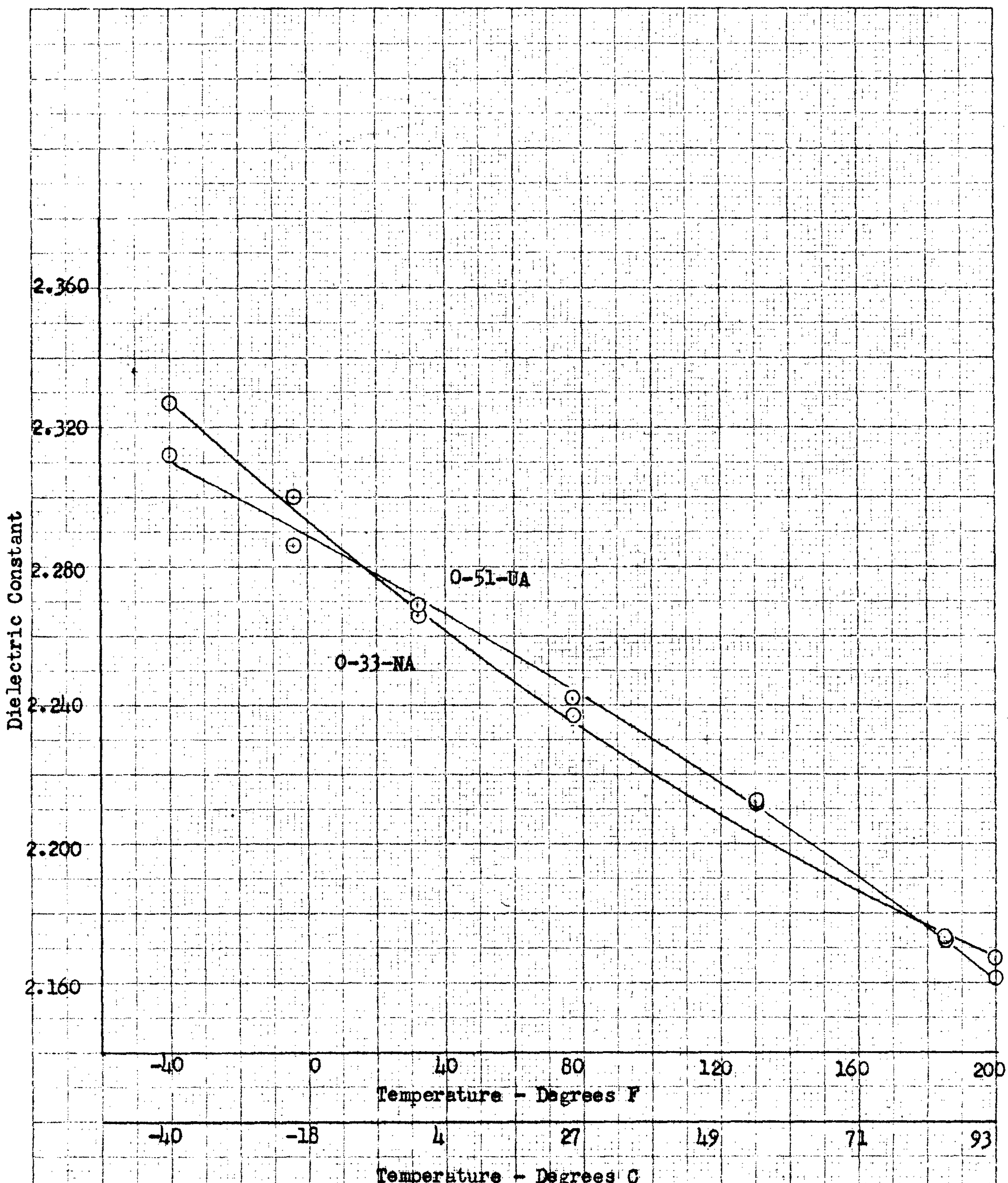


Fig. 9

Dielectric Constant vs. Temperature at 400 cps
Grade 1065 Pair Samples

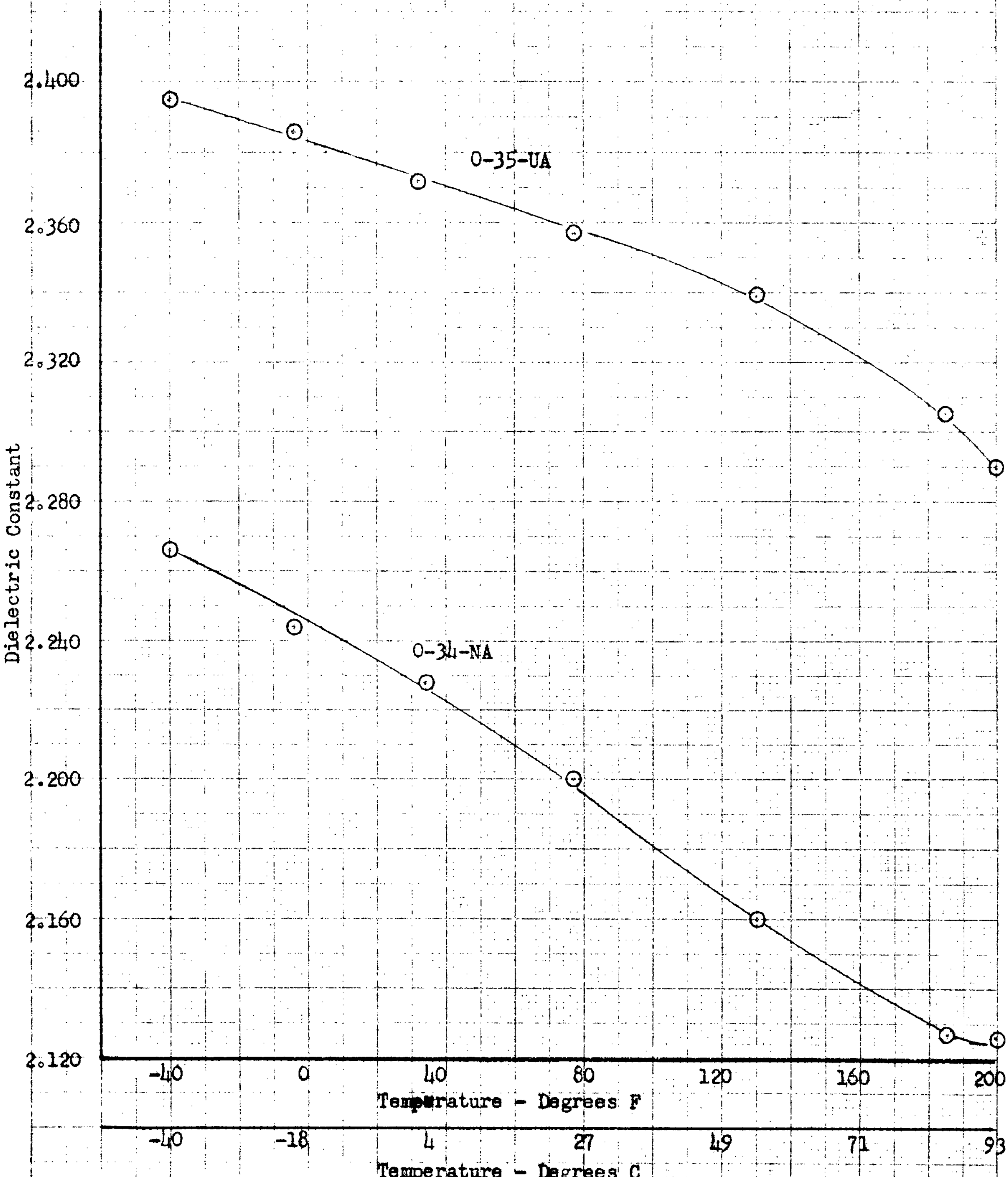


Fig. 10

Dielectric Constant vs. Temperature at 400 cps
Grade 1010 Pair Samples

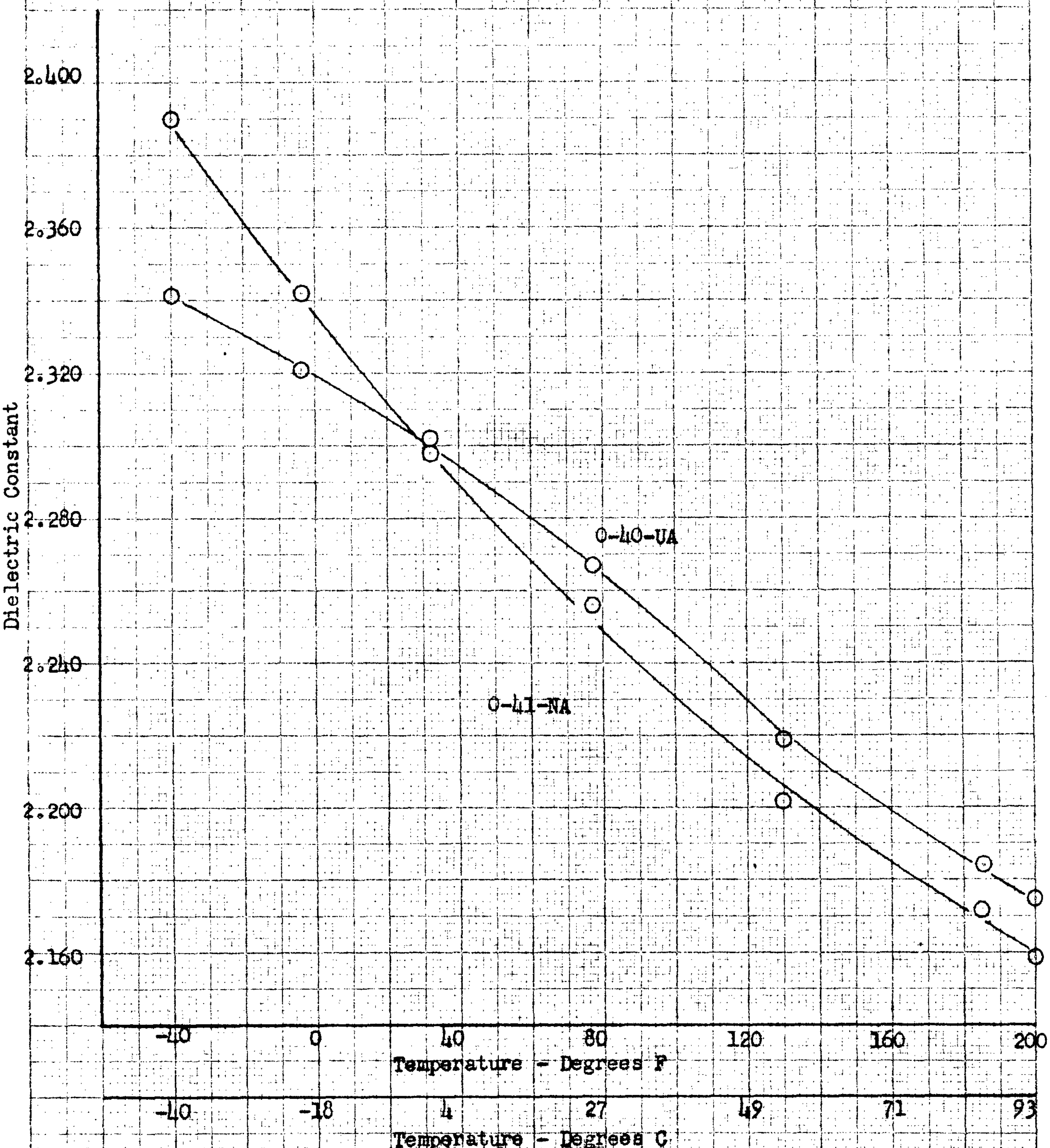


Fig. 11
Dielectric Constant vs. Temperature at 400 cps
Hydraulic Oil Pair Samples

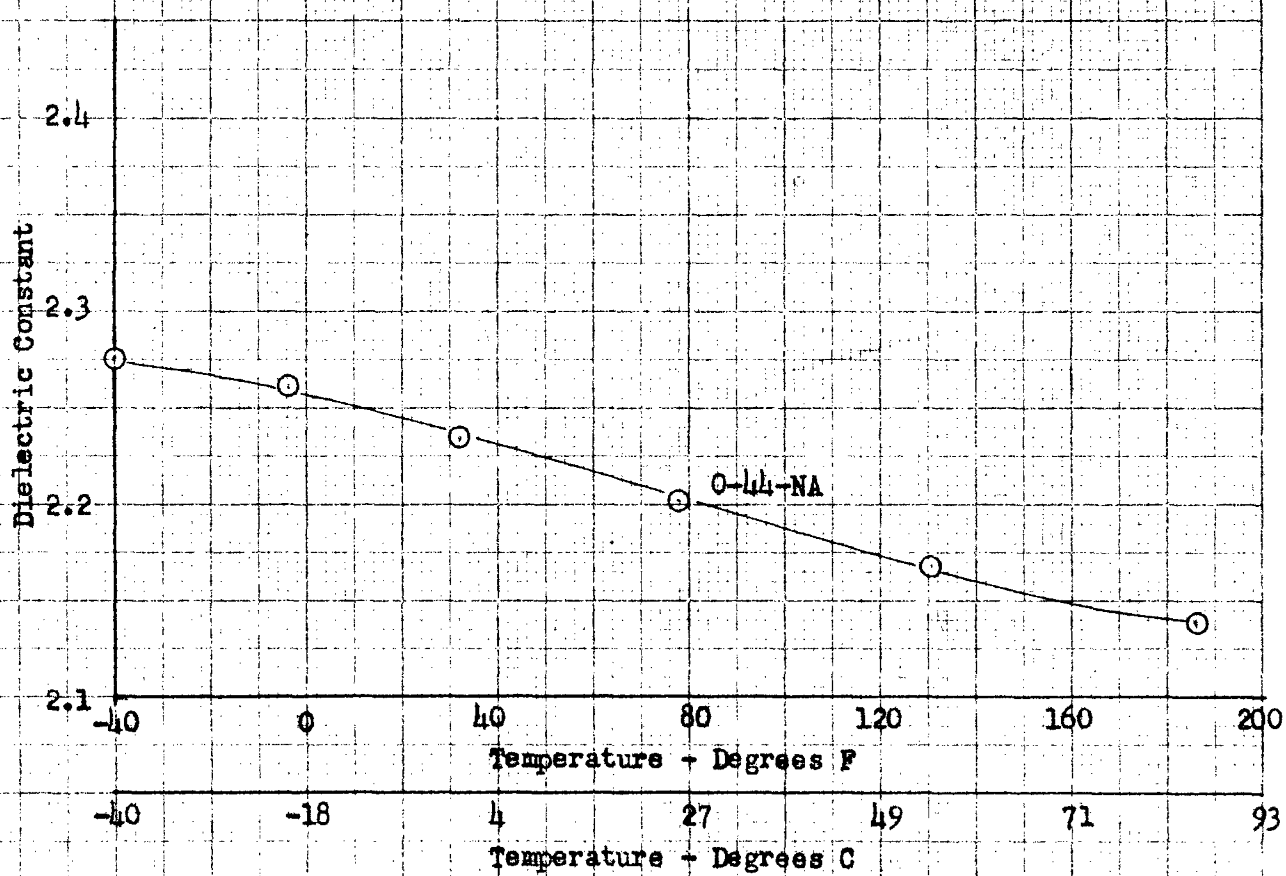


Fig. 12
Dielectric Constant vs. Temperature at 400 cps
New Oil Specimens From Air Force Bases

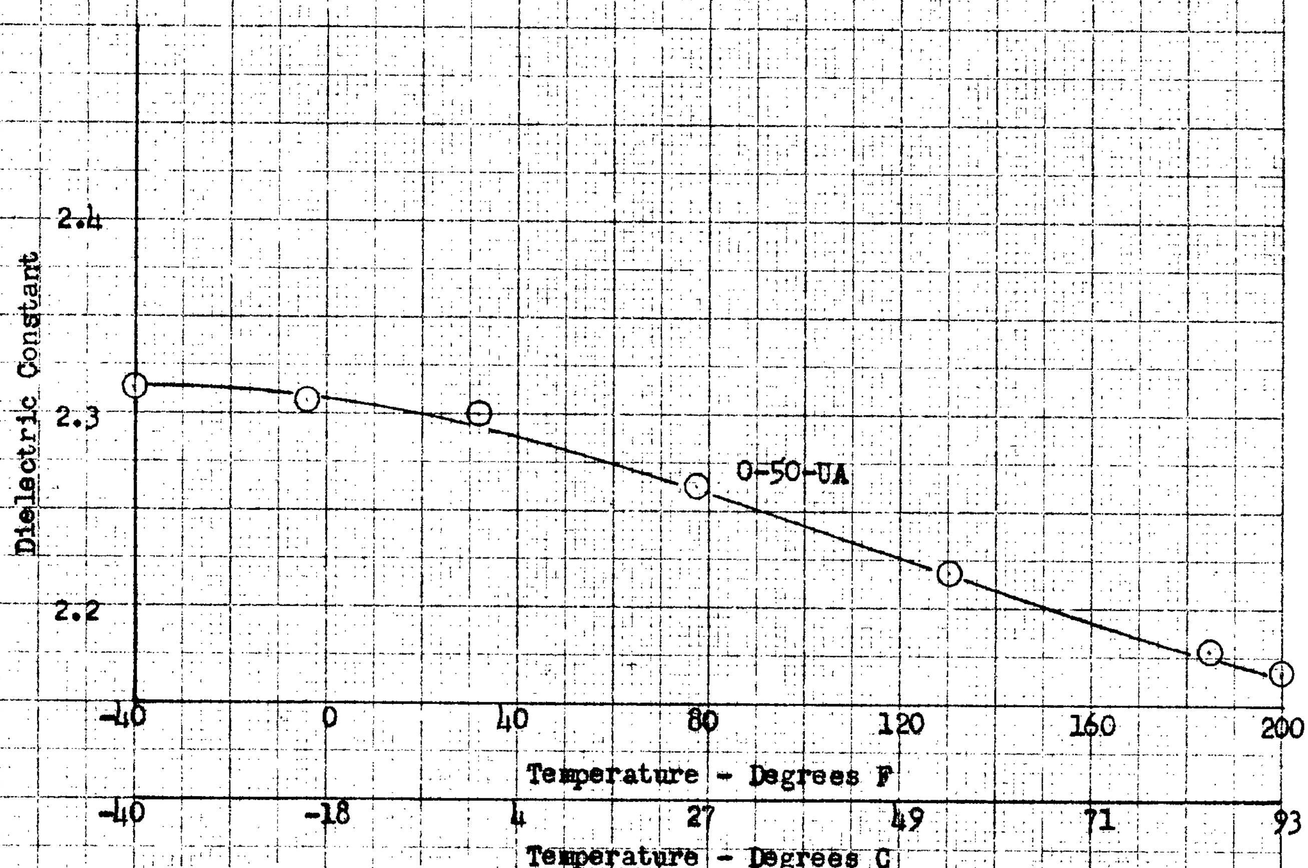


Fig. 13

Dielectric Constant vs. Temperature at 400 cps

Used Oil Specimens From Air Force Bases

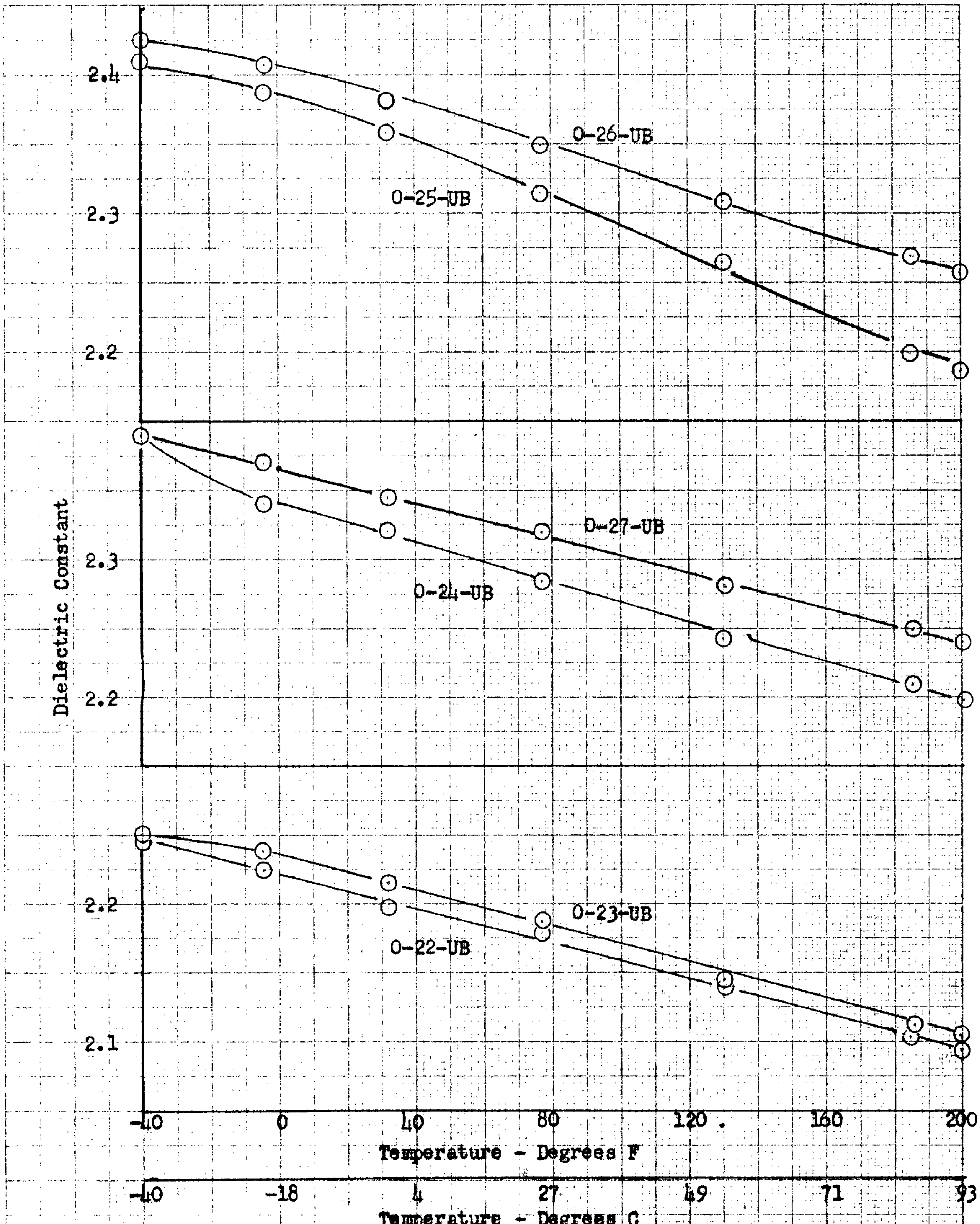


Fig. 14

Dielectric Constant vs. Temperature at 400 cps
Used Oils Specimens from Aircraft

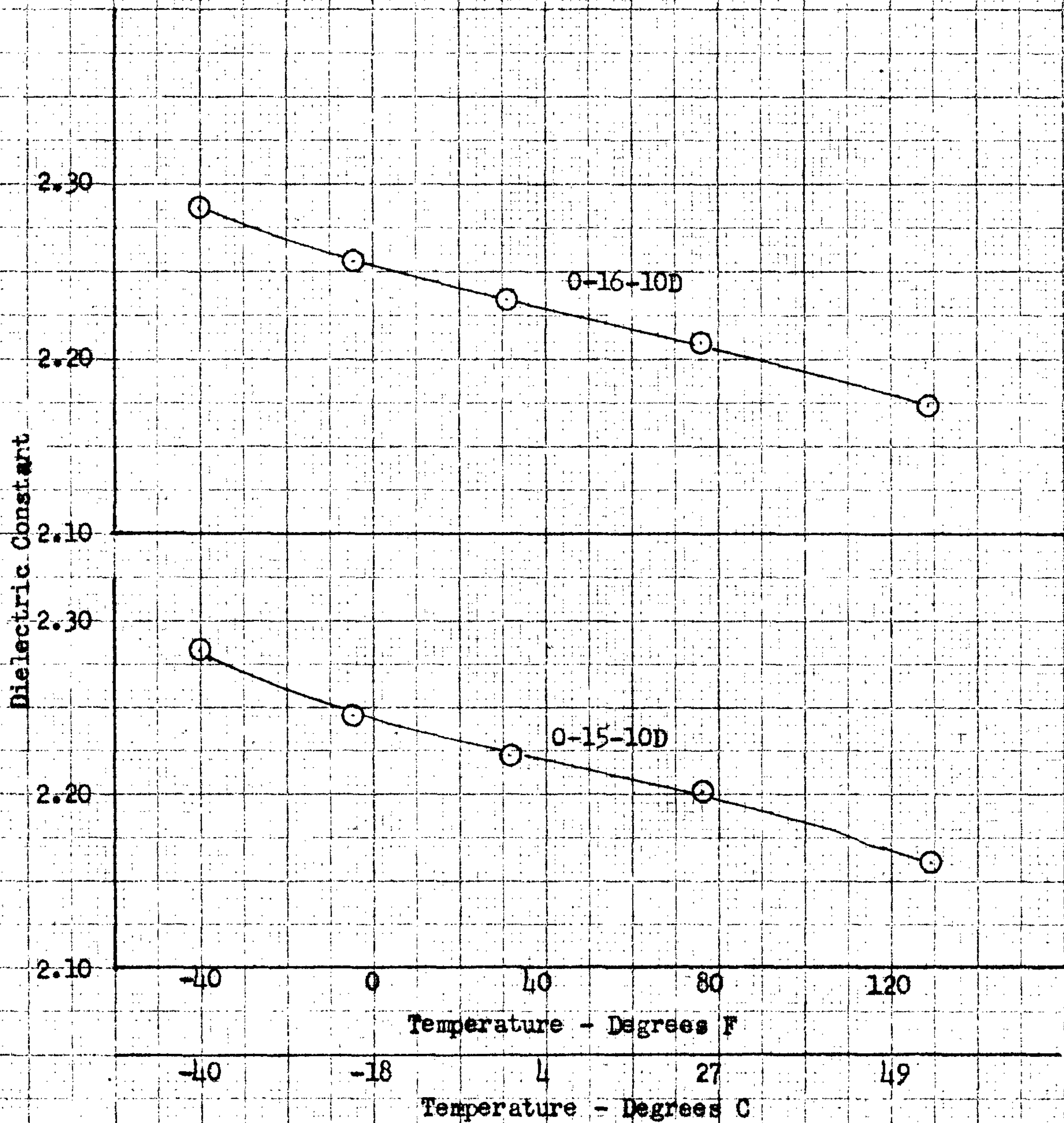


Fig. 15

Dielectric Constant vs. Temperature at 400 cps

10% Diluted Specimens

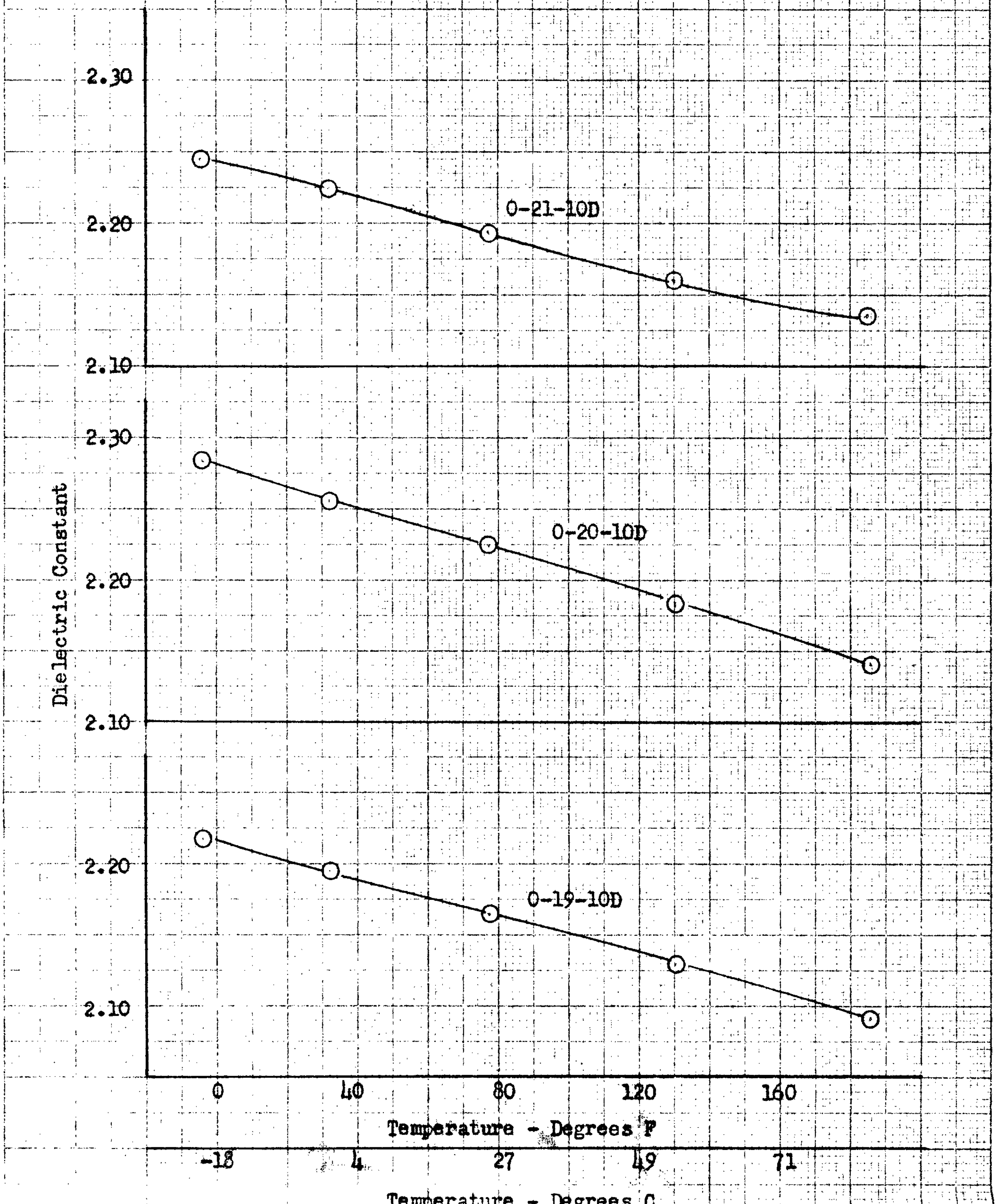


Fig. 16

Dielectric Constant vs. Temperature at 400 cps

10% Diluted Specimens

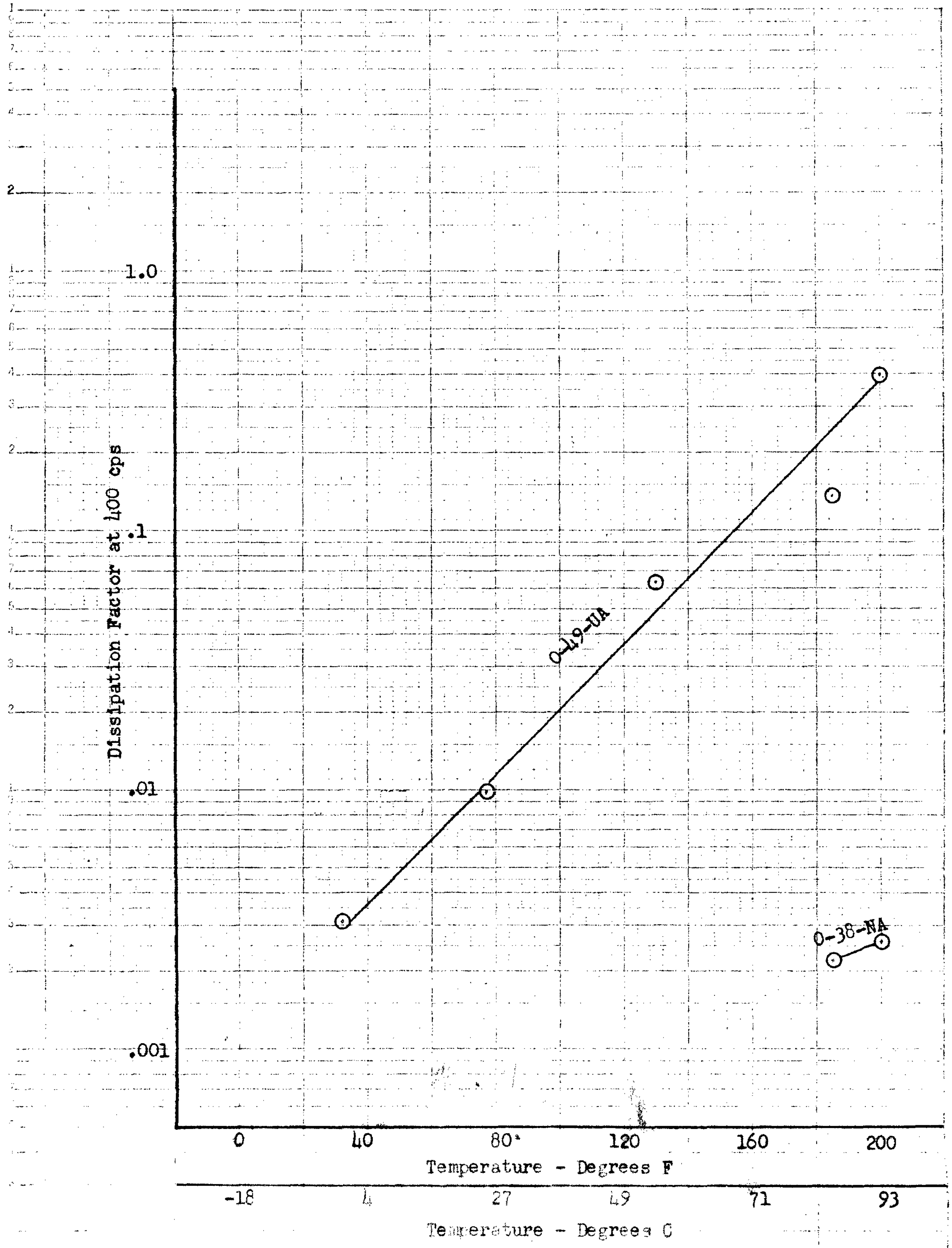


Fig. 17

Dissipation Factor vs. Temperature at 400 cps Grade 1100 Pair Samples

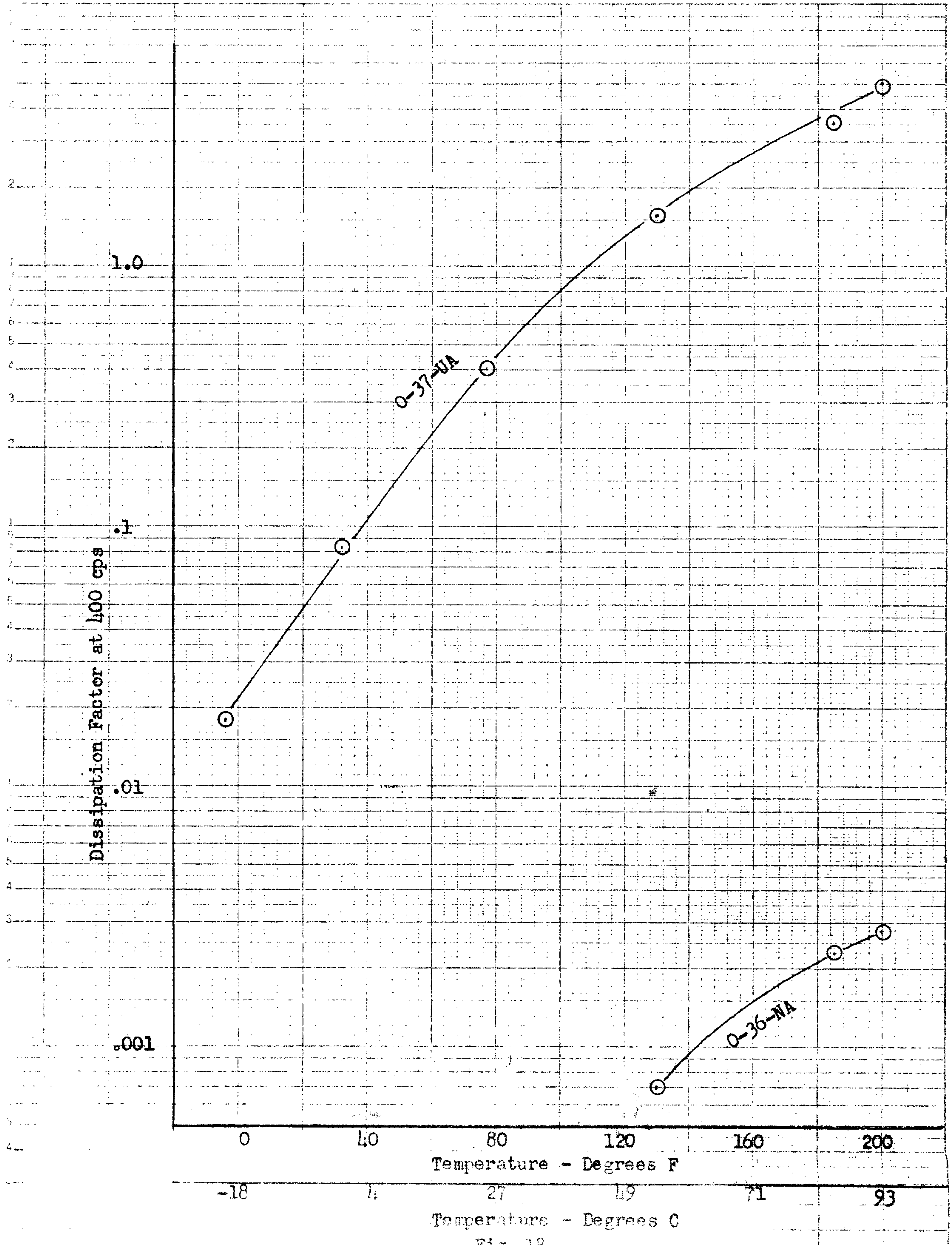


Fig. 18

Dissipation Factor vs. Temperature at 400 cps Grade 1050 Pair Samples

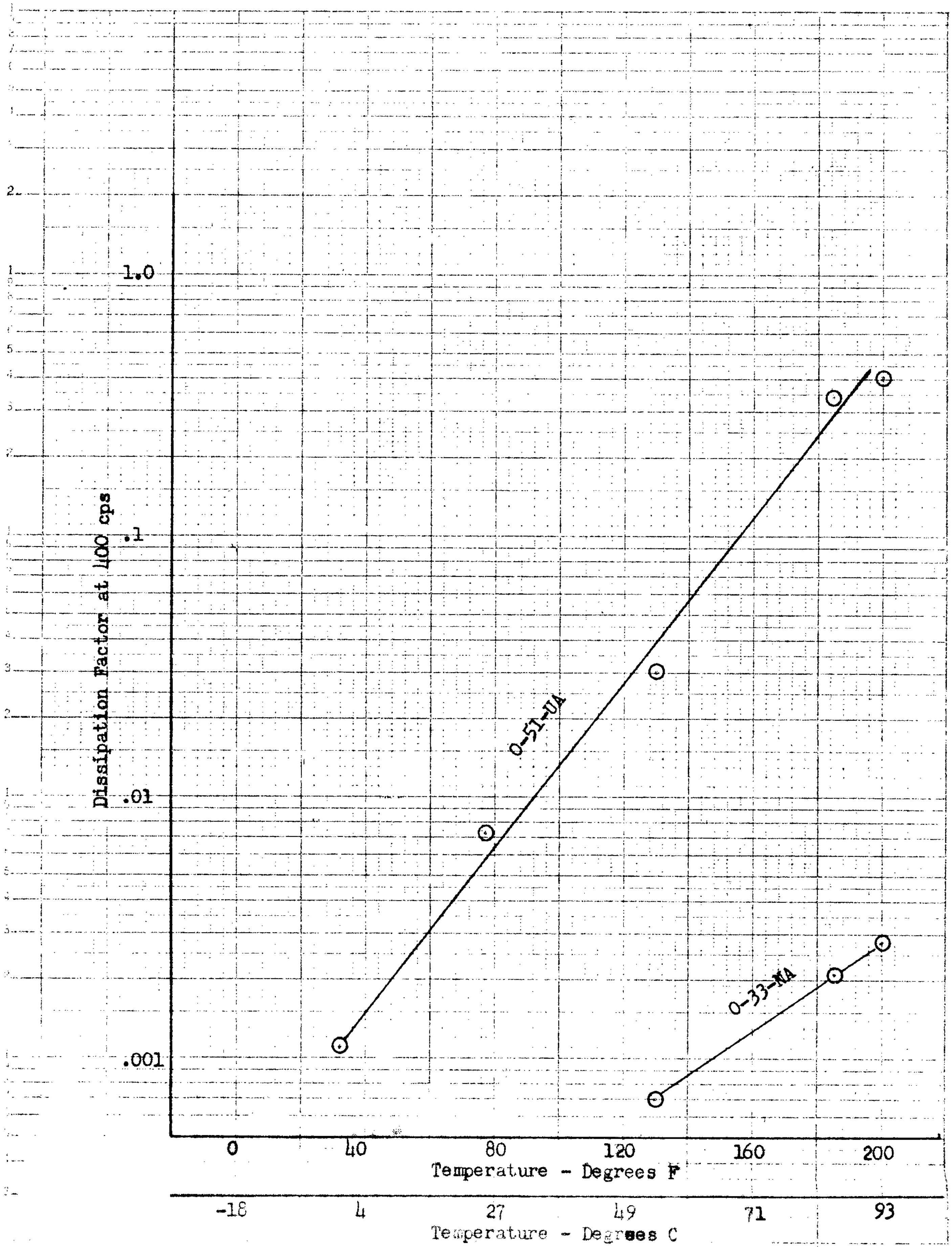


Fig. 19

Dissipation Factor vs. Temperature at 400 cps Grade 1065 Pair Samples

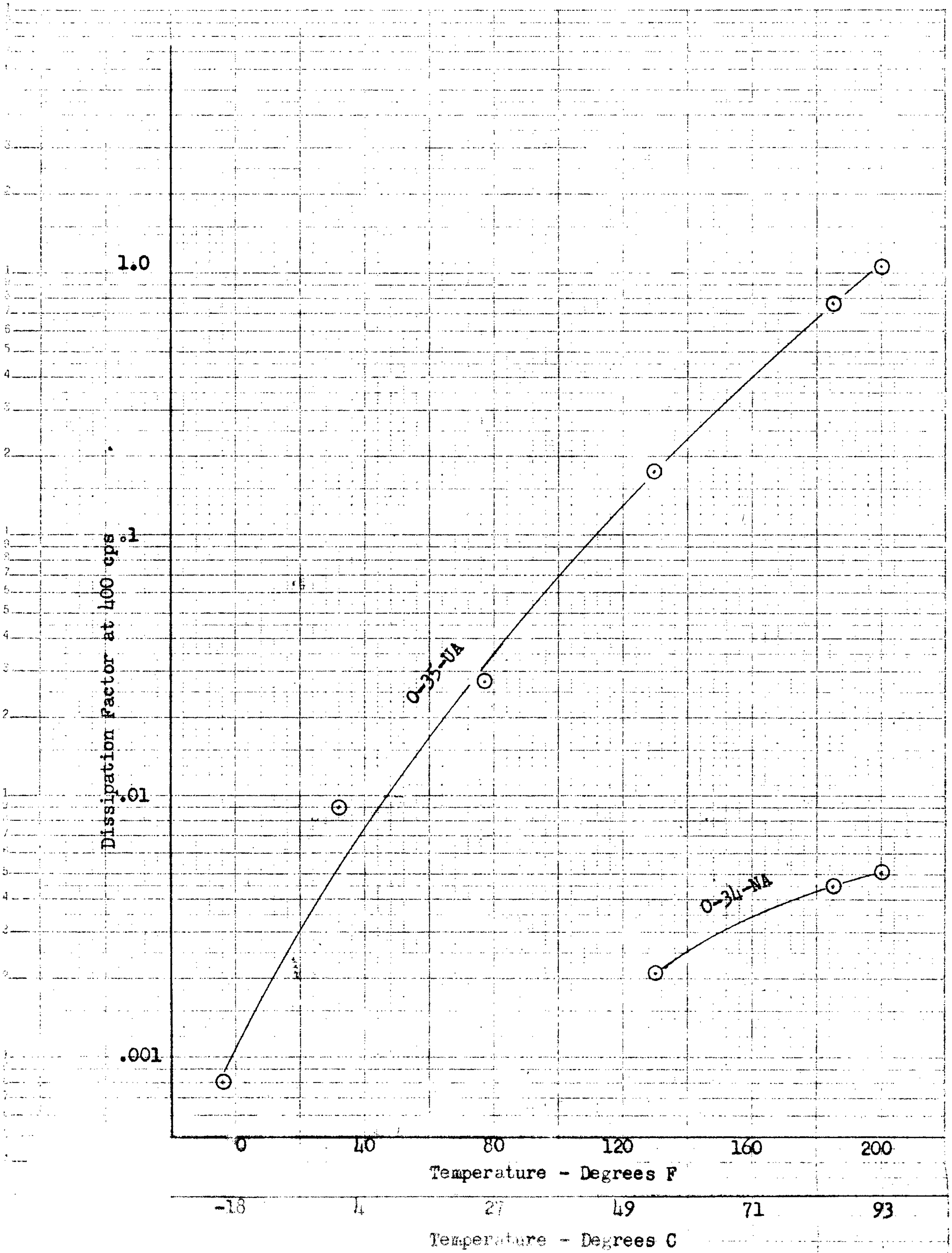


Fig. 20

Dissipation Factor vs. Temperature at 400 cps Grade 1010 Pair Samples

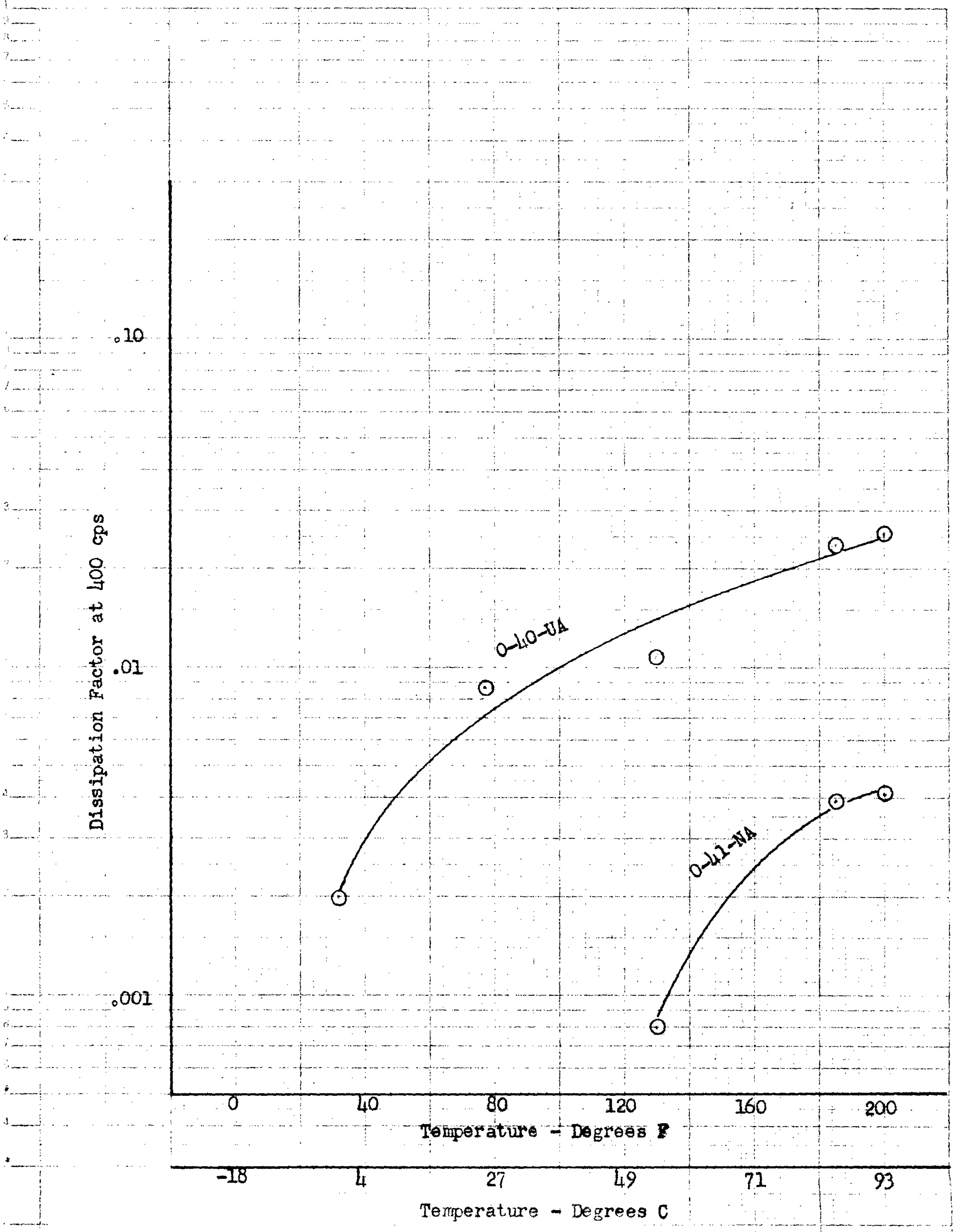


Fig. 21
Dissipation Factor vs. Temperature at 400 cps Hydraulic Oil Pair Samples

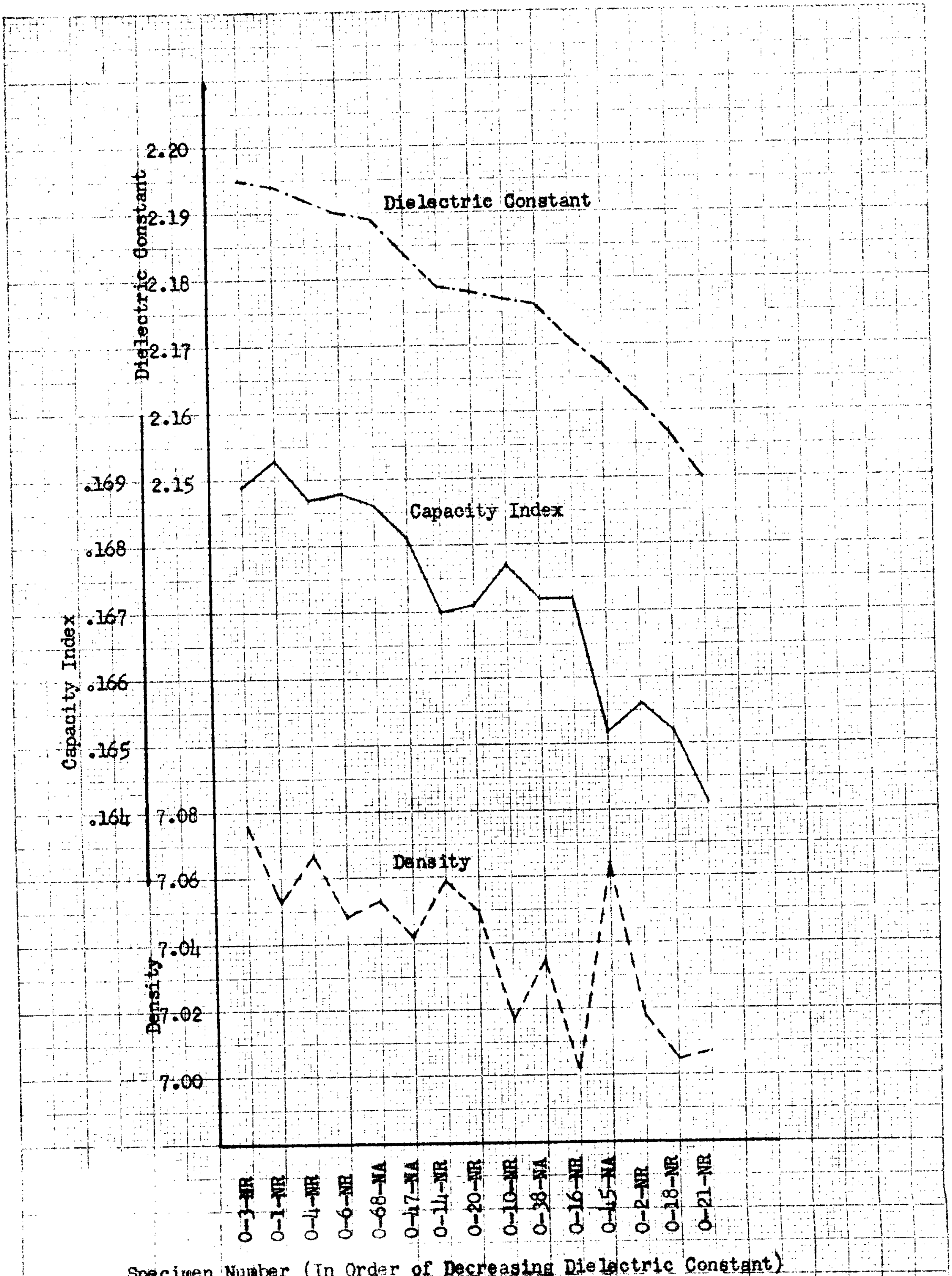
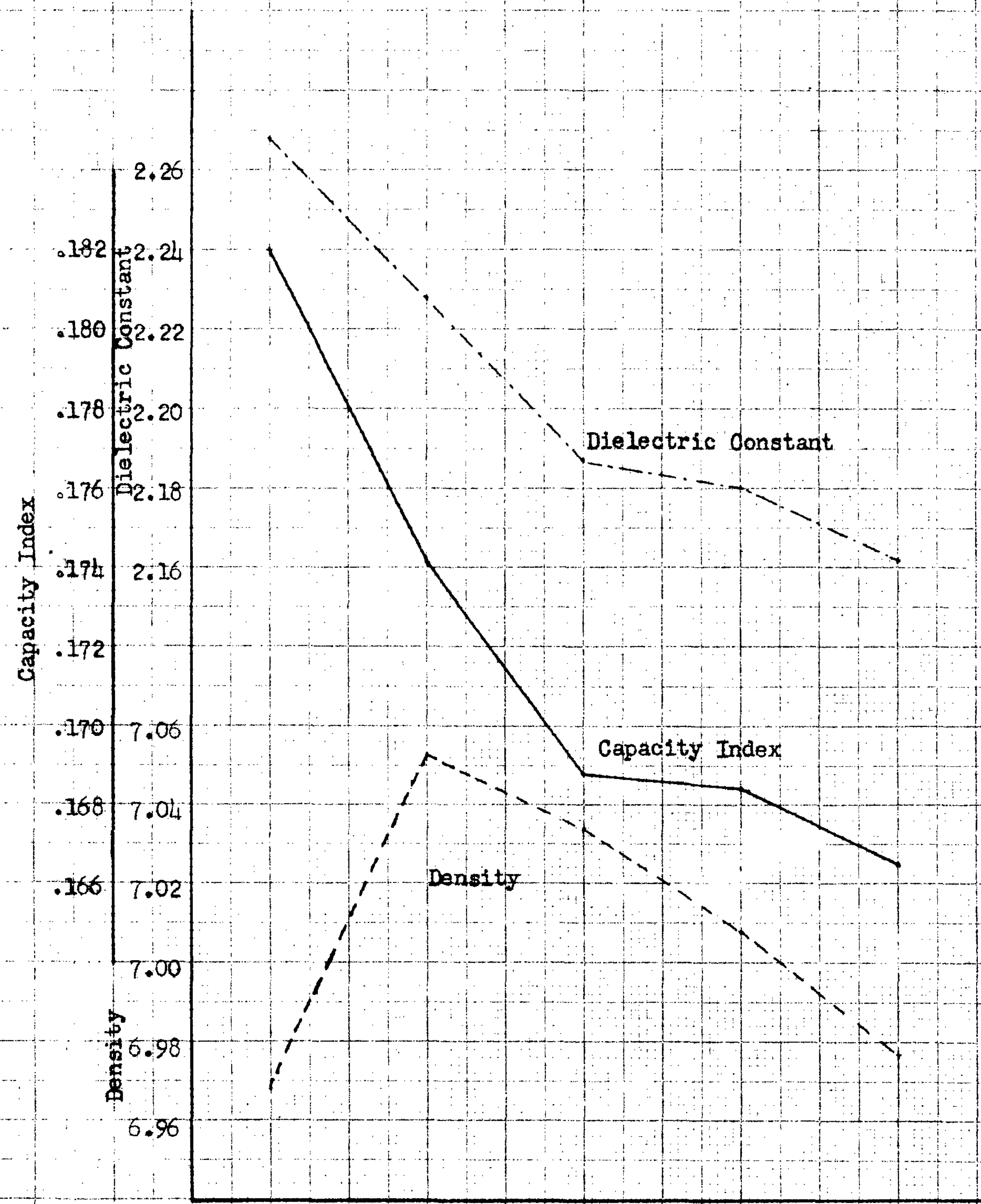


Fig. 22

Grade 1100 New Oil Characteristics at 400 cps, 185°F(85°C)



Specimen Number (In Order of Decreasing Dielectric Constant)

Fig. 23

Grade 1080 New Oil Characteristics at 400 cps, 185°F(85°C)

0-67-NA
0-36-NA
0-52-NA
0-11-NR
0-13-NR

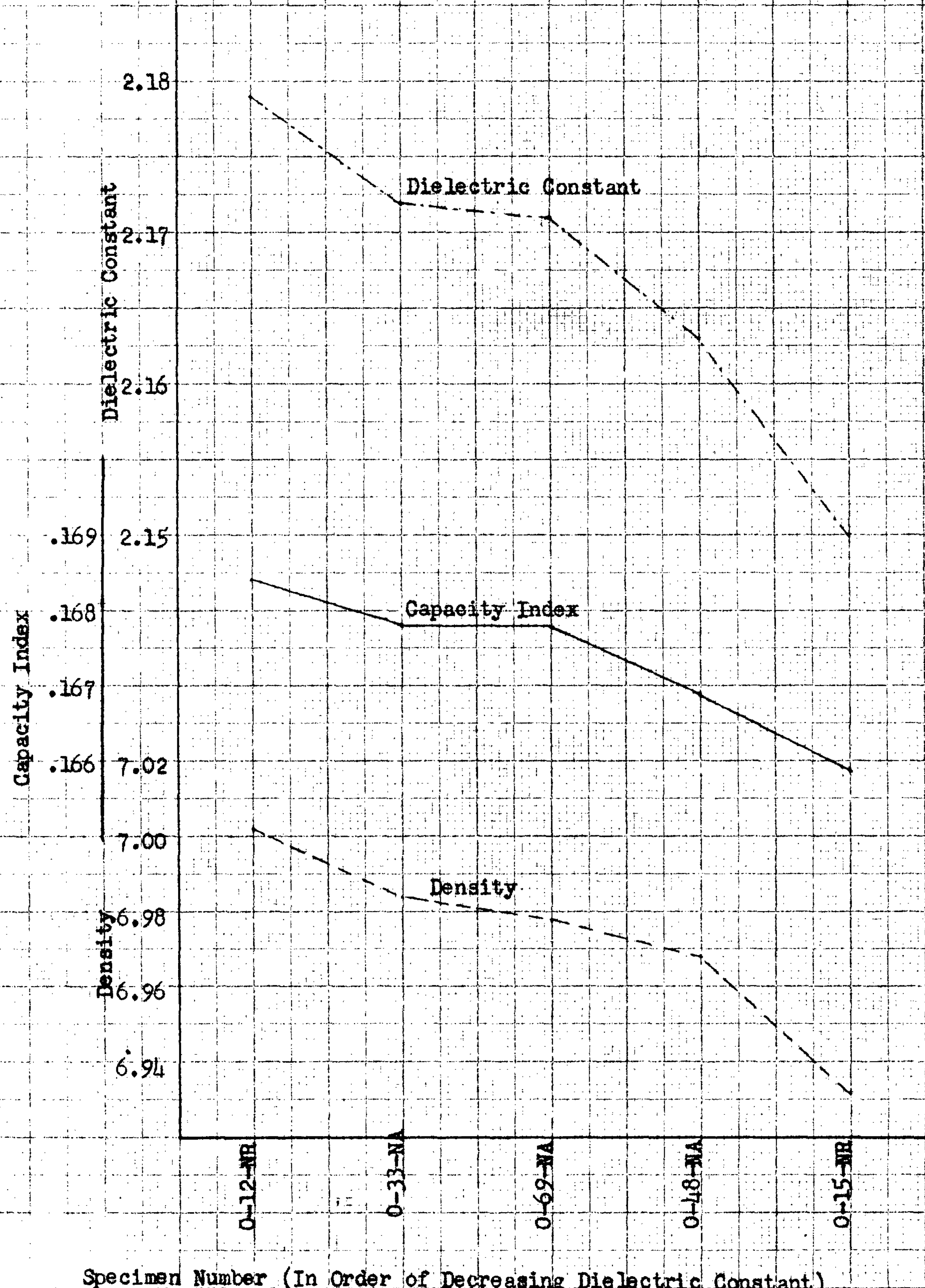
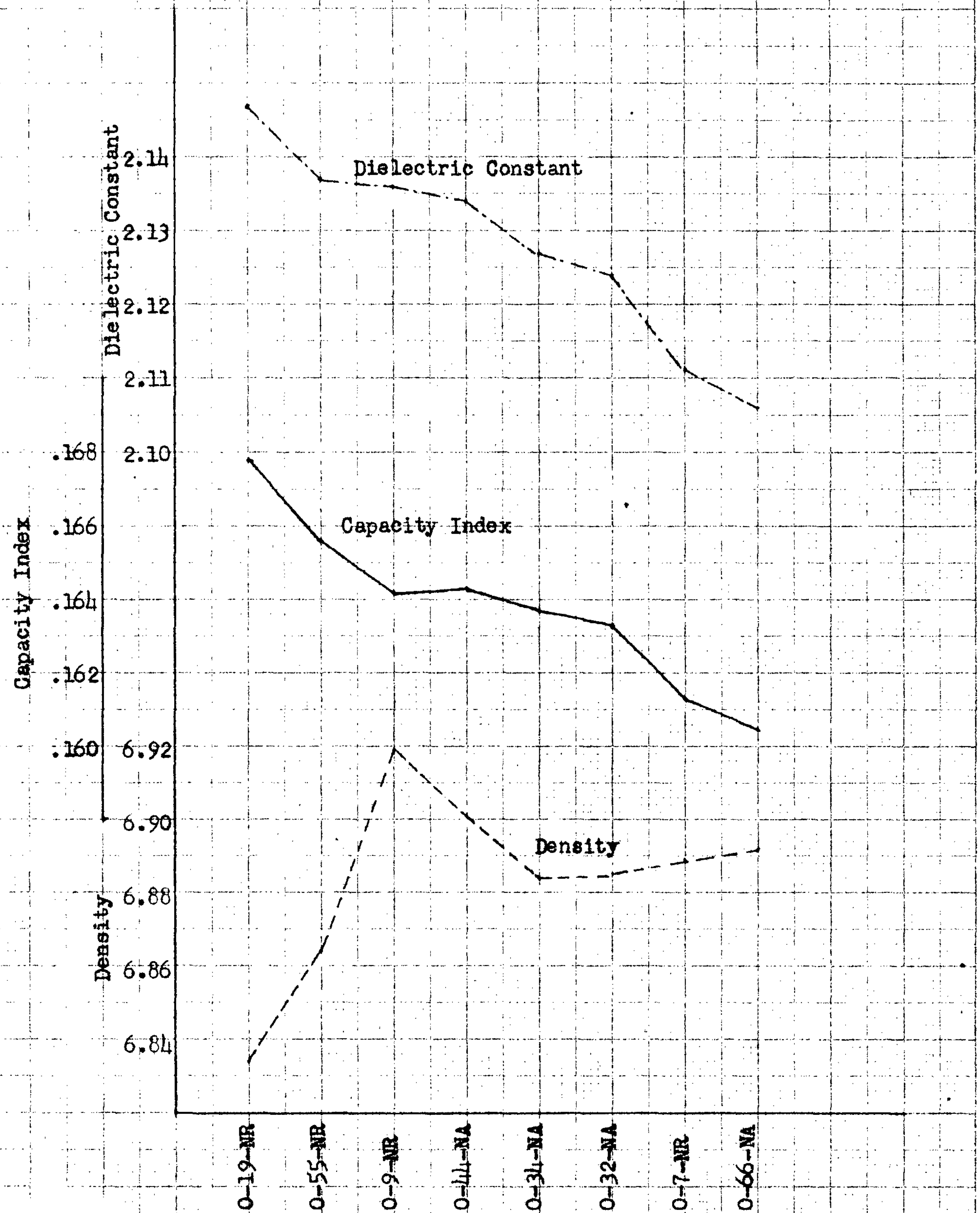


Fig. 24

Grade 1065 New Oil Characteristics at 400 cps, 185°F(85°C)



Specimen Number (In Order of Decreasing Dielectric Constant)

Fig. 25

Grade 1010 New Oil Characteristics at 400 cps, 185°F(85°C)

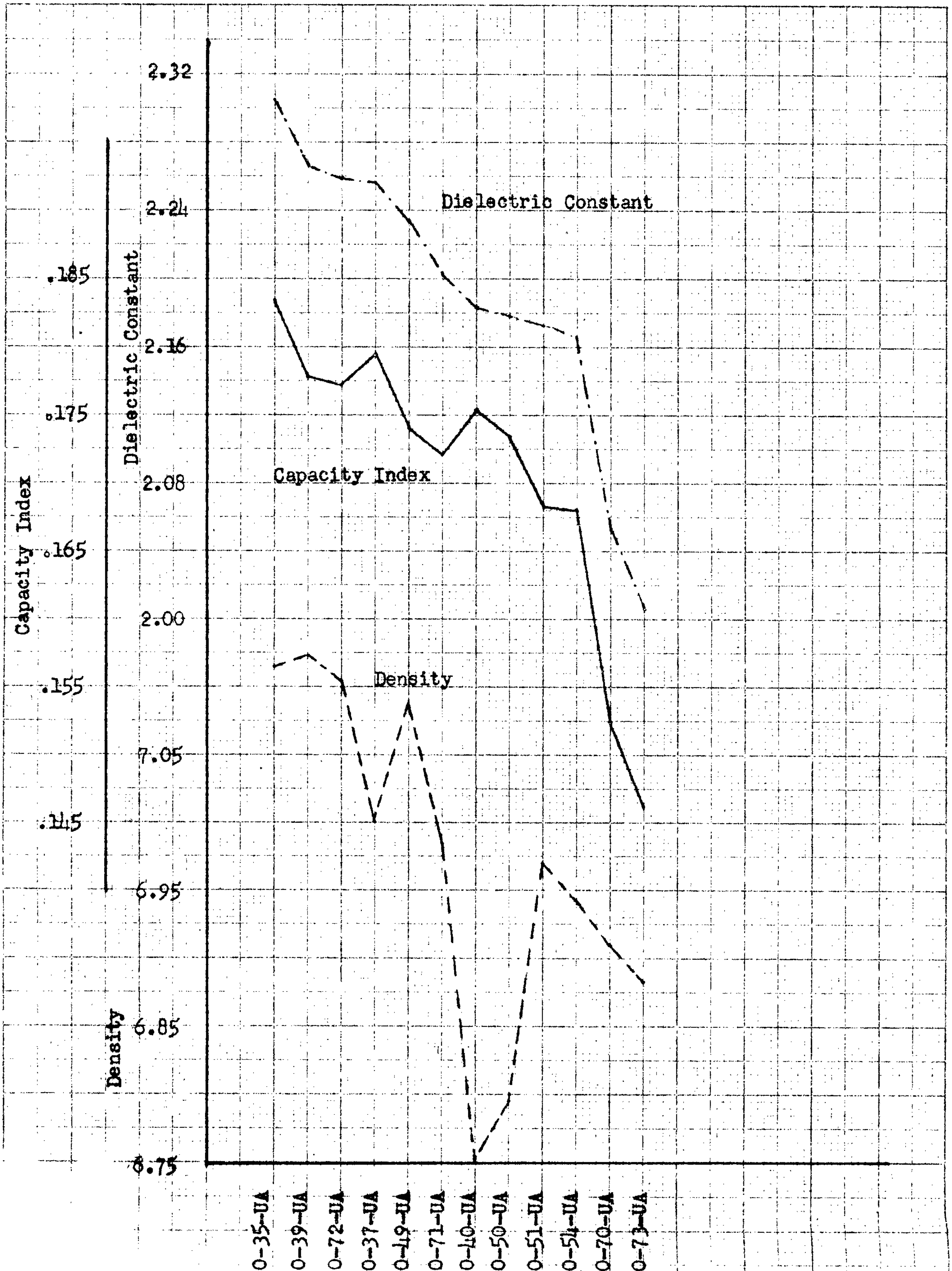


Fig. 26

UA Oil Characteristics at 400 cps, 185°F(85°C)

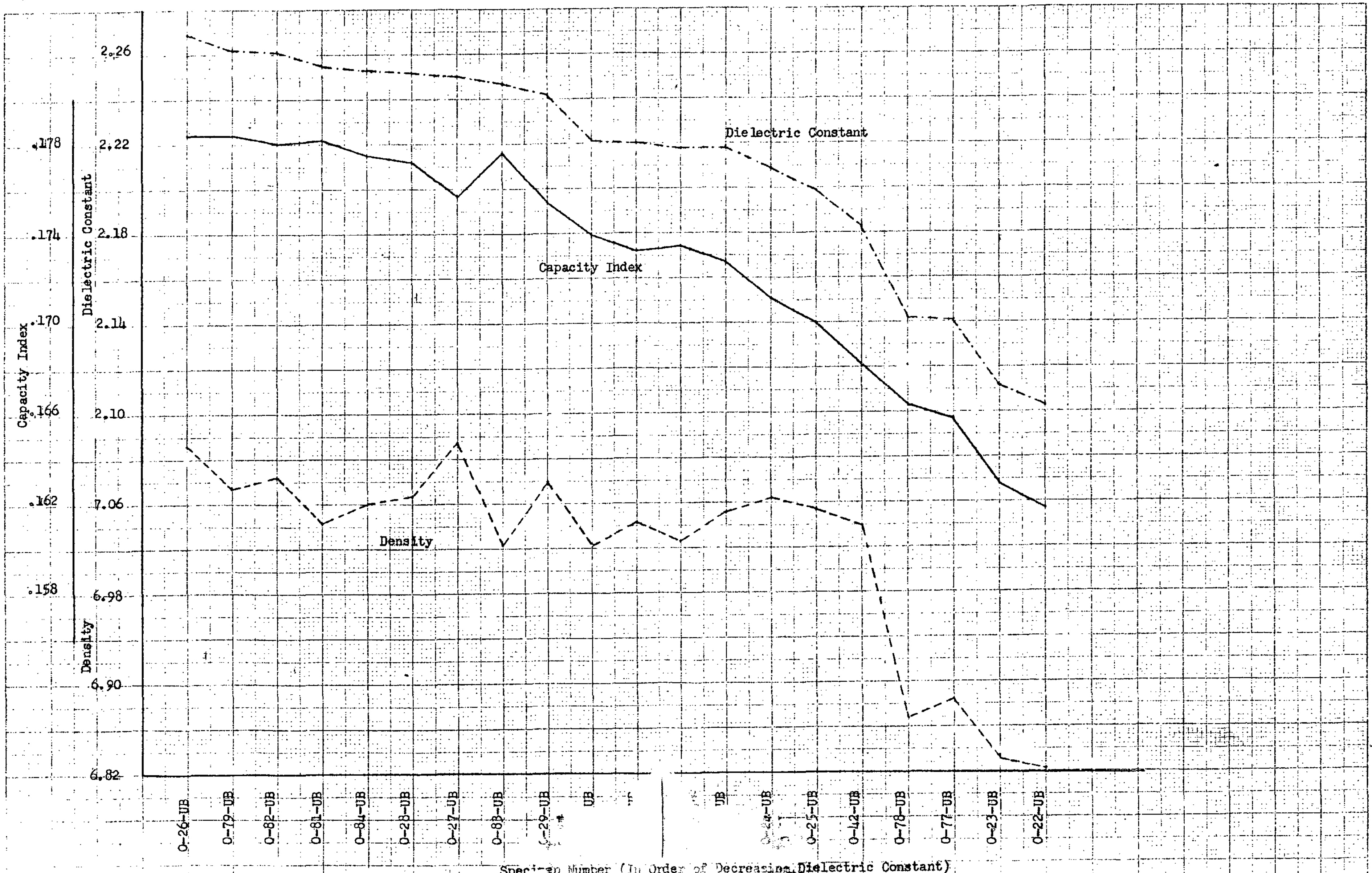
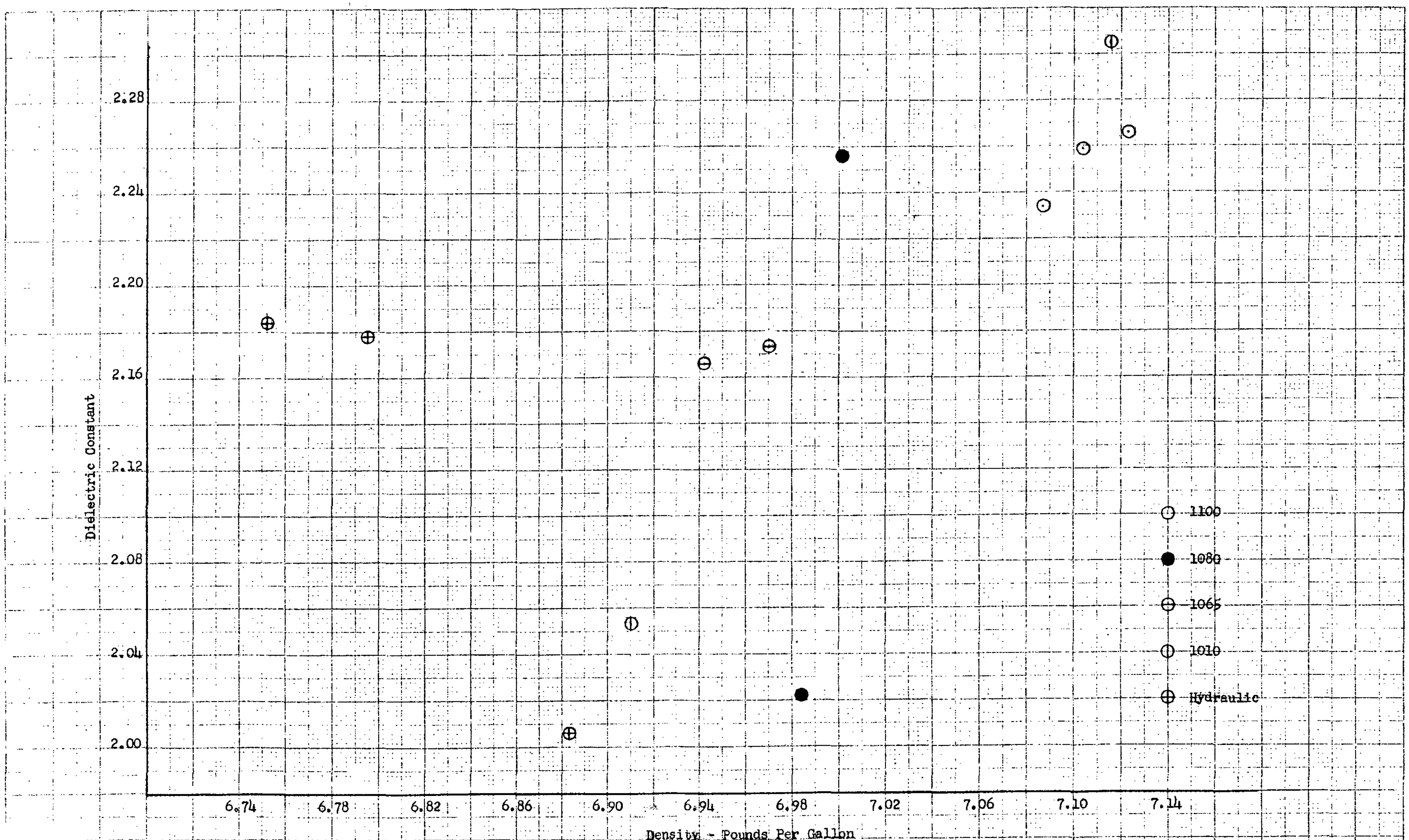


Fig. 27
UB Oil Characteristics at 400 cps, 185°F(85°C)



Fi

Used Oil Characteristics at 185°F(85°C), 400 cps
UA Specimens

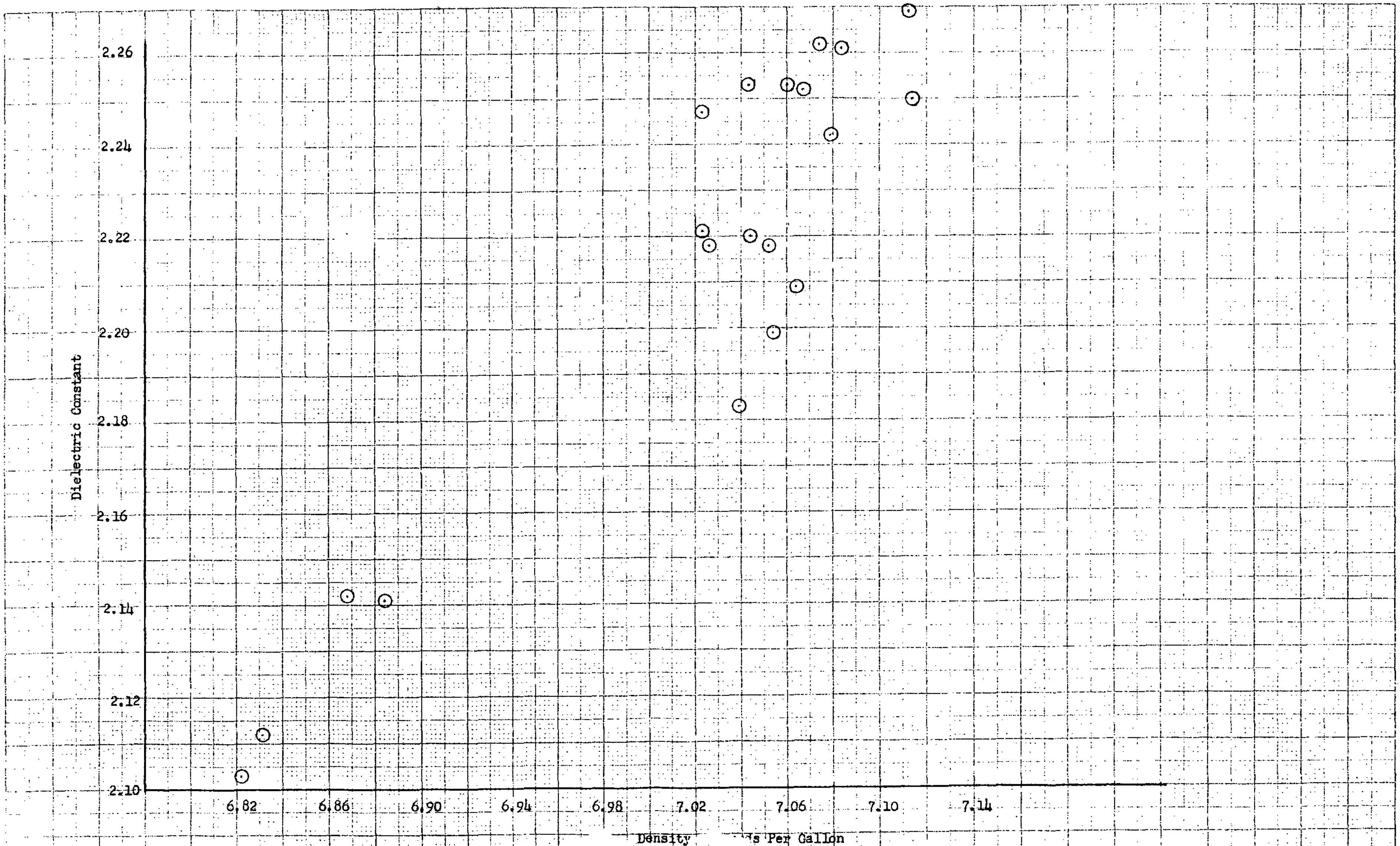


Fig. 29

Used Oil Characteristics a. (85°C), 400 cps

UB Specimens

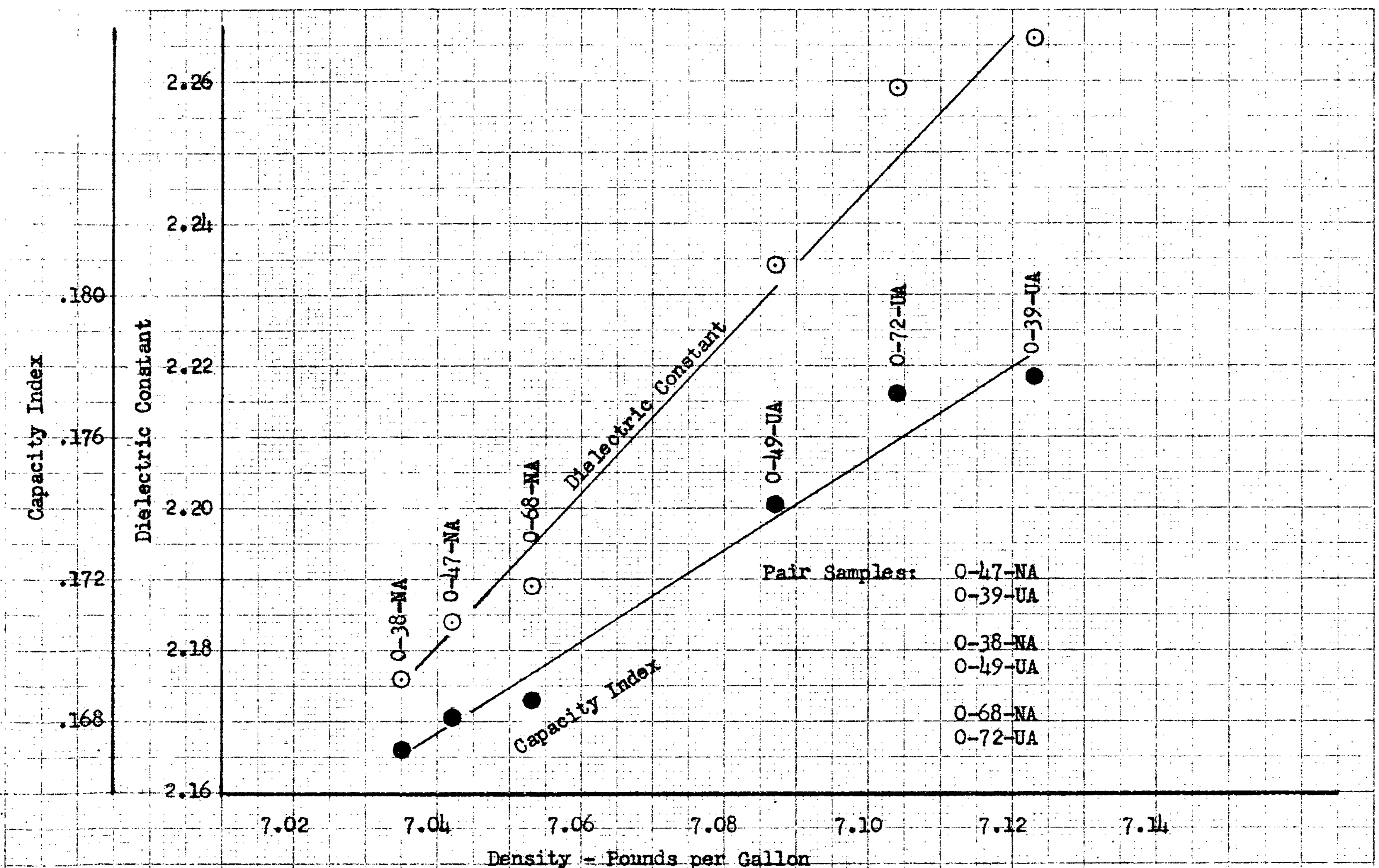


Fig. 30

Oil Characteristics at 185°F(85°C), 400 cps

Grade 1100 Pair Samples

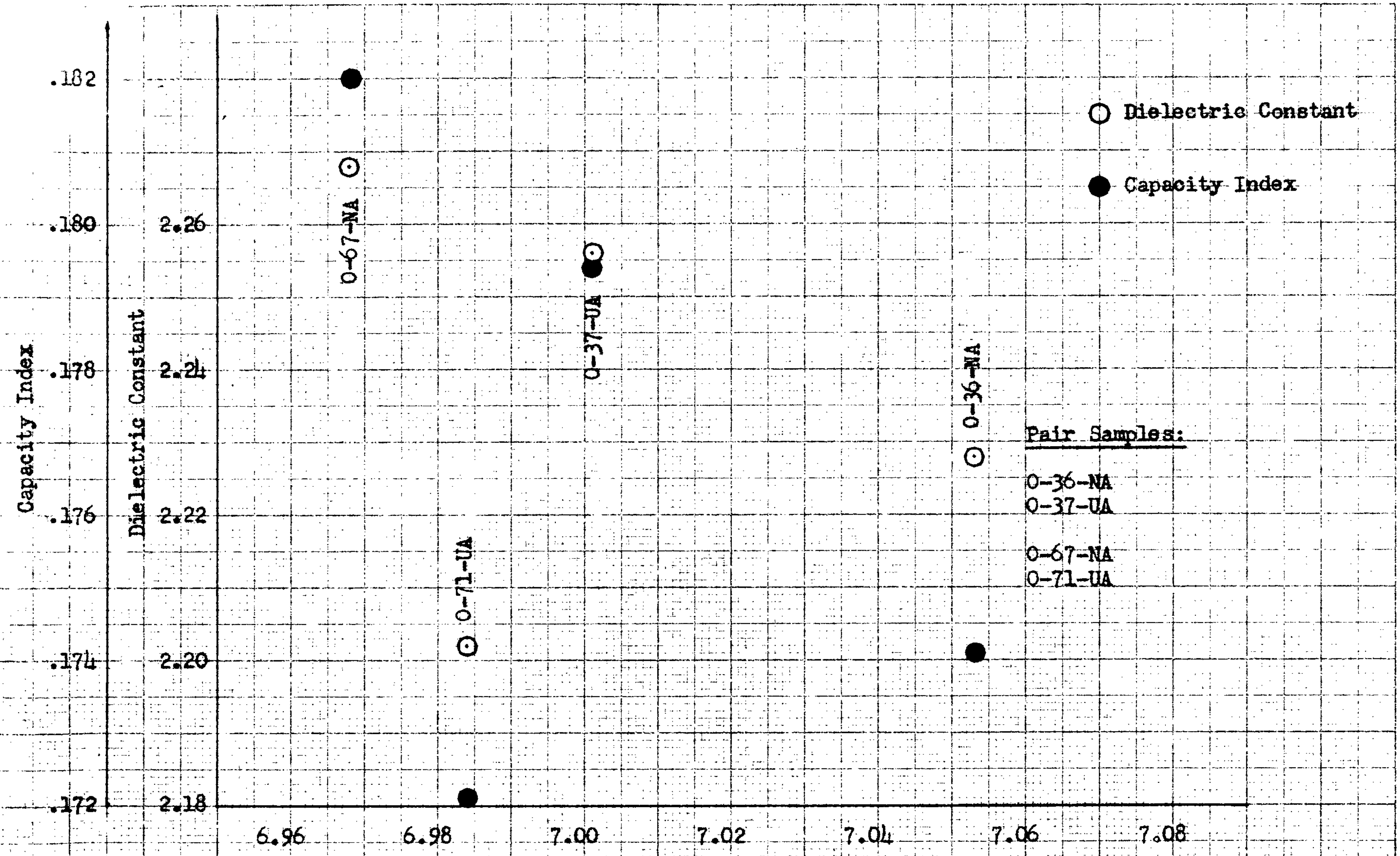


Fig. 31
Oil Characteristics at 185°F(85°C), 400 cps

Grade 1080 Pair Samples

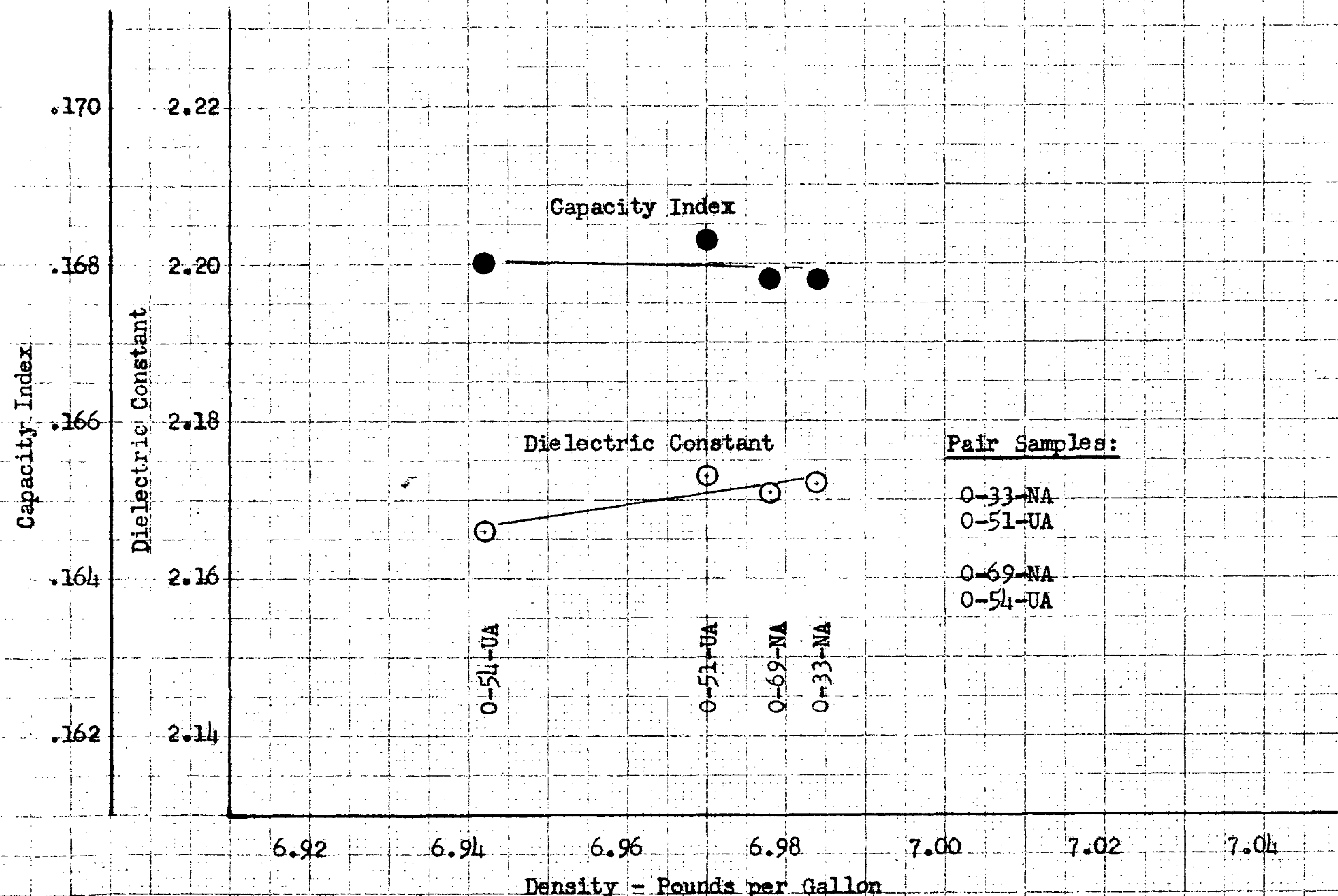


Fig. 32

Oil Characteristics at 185°F(85°C), 400 cps

Grade 1065 Pair Samples

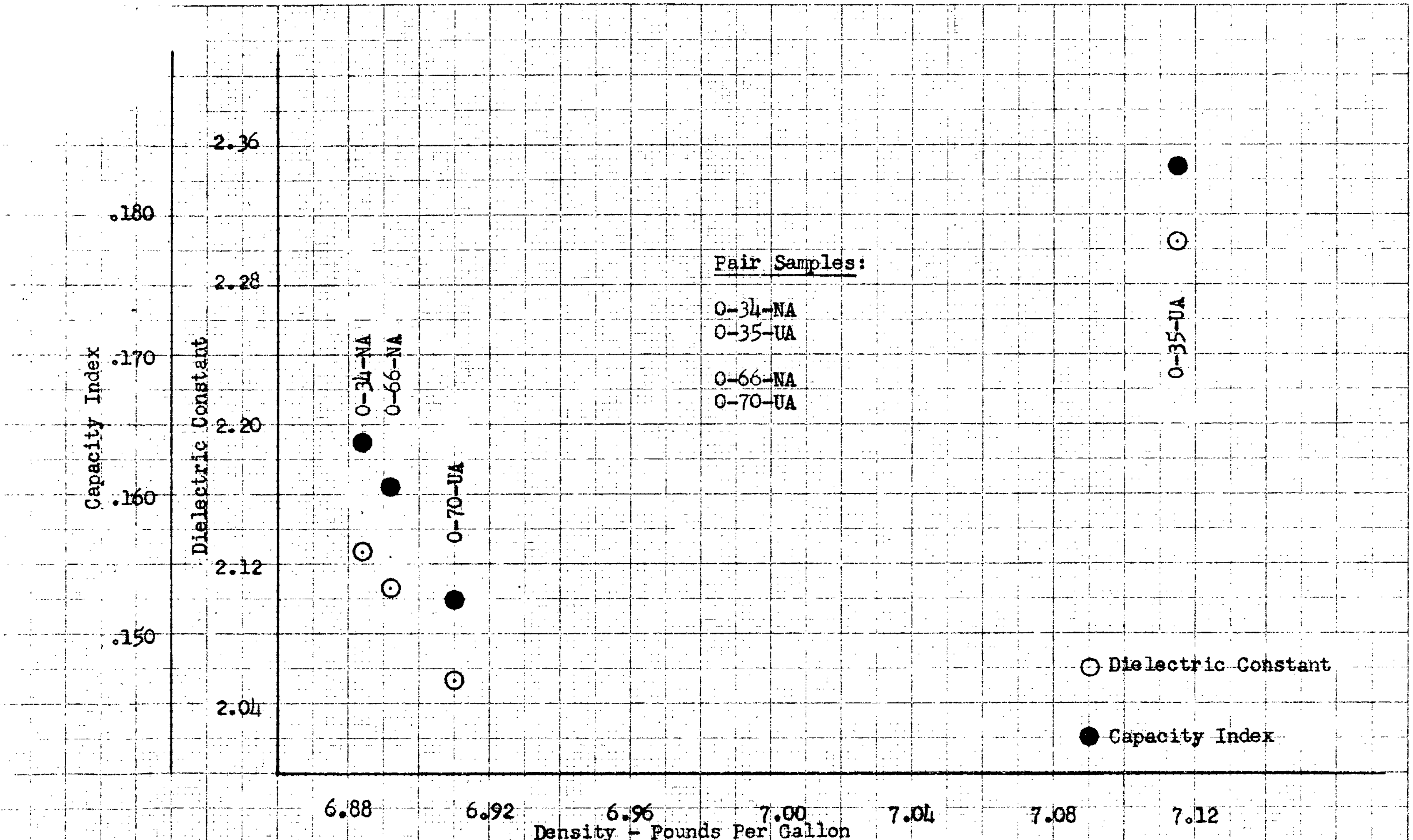


Fig. 33

Oil Characteristics at 185°F (85°C), 400 cps

Grade 1010 Pair Samples

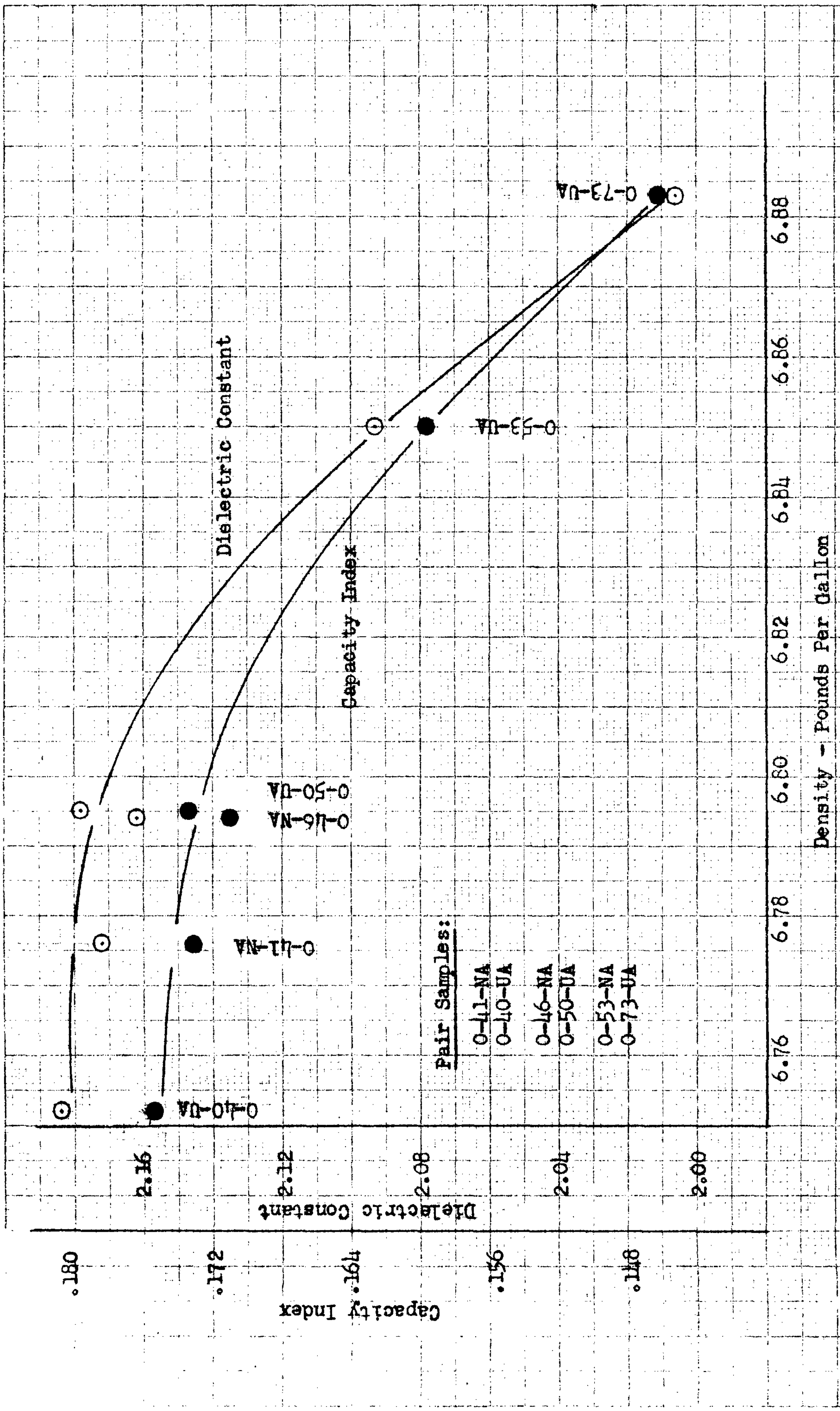


Fig. 34

Oil Characteristics at 185°F (85°C), 400 cps

Hydraulic Oil Pair Samples

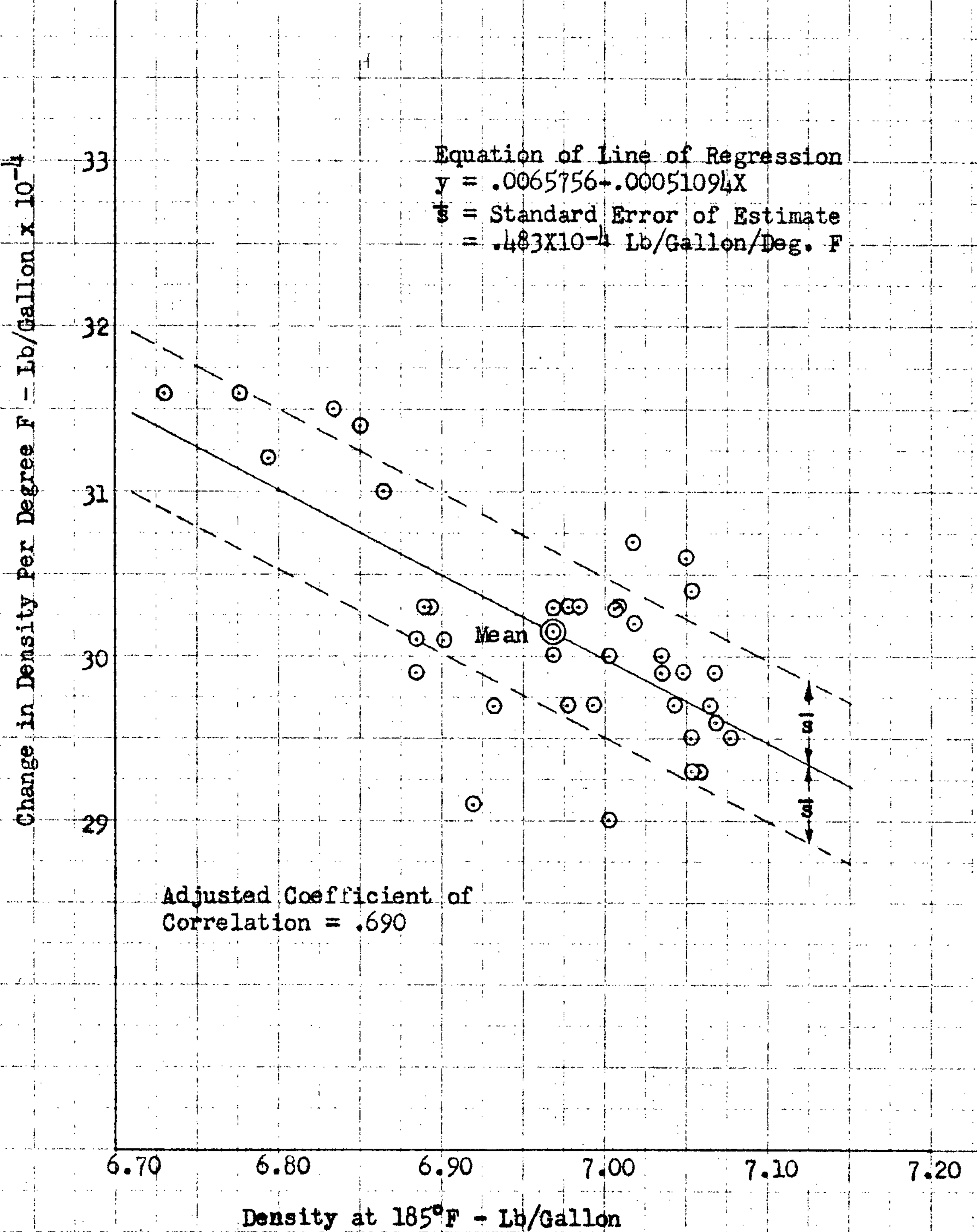


Fig. 35

Slope of Density vs. Temperature Curves as a Function of Density (New Oils)

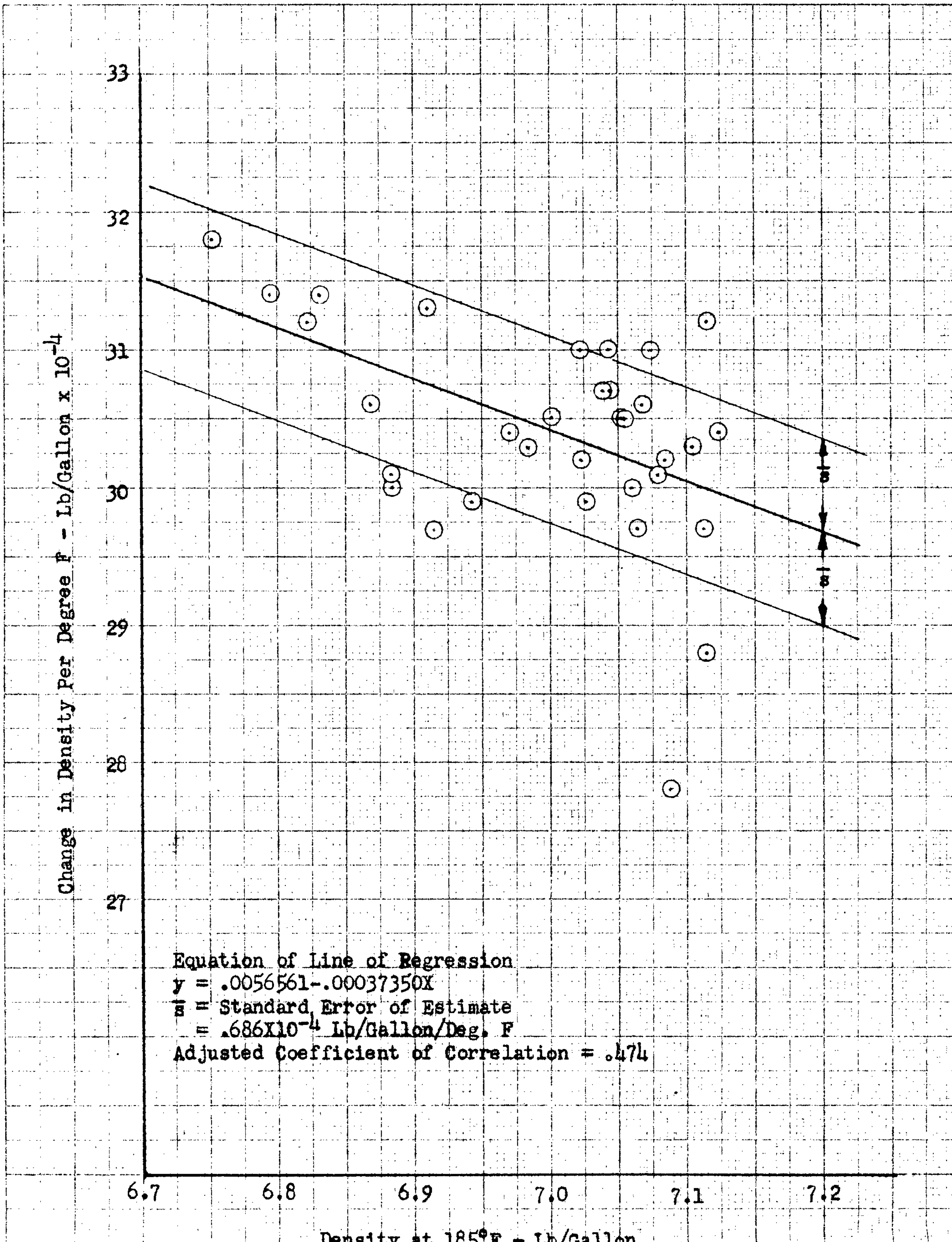


Fig. 36

Slope of Density vs. Temperature Curves as a Function of Density - Used Oils

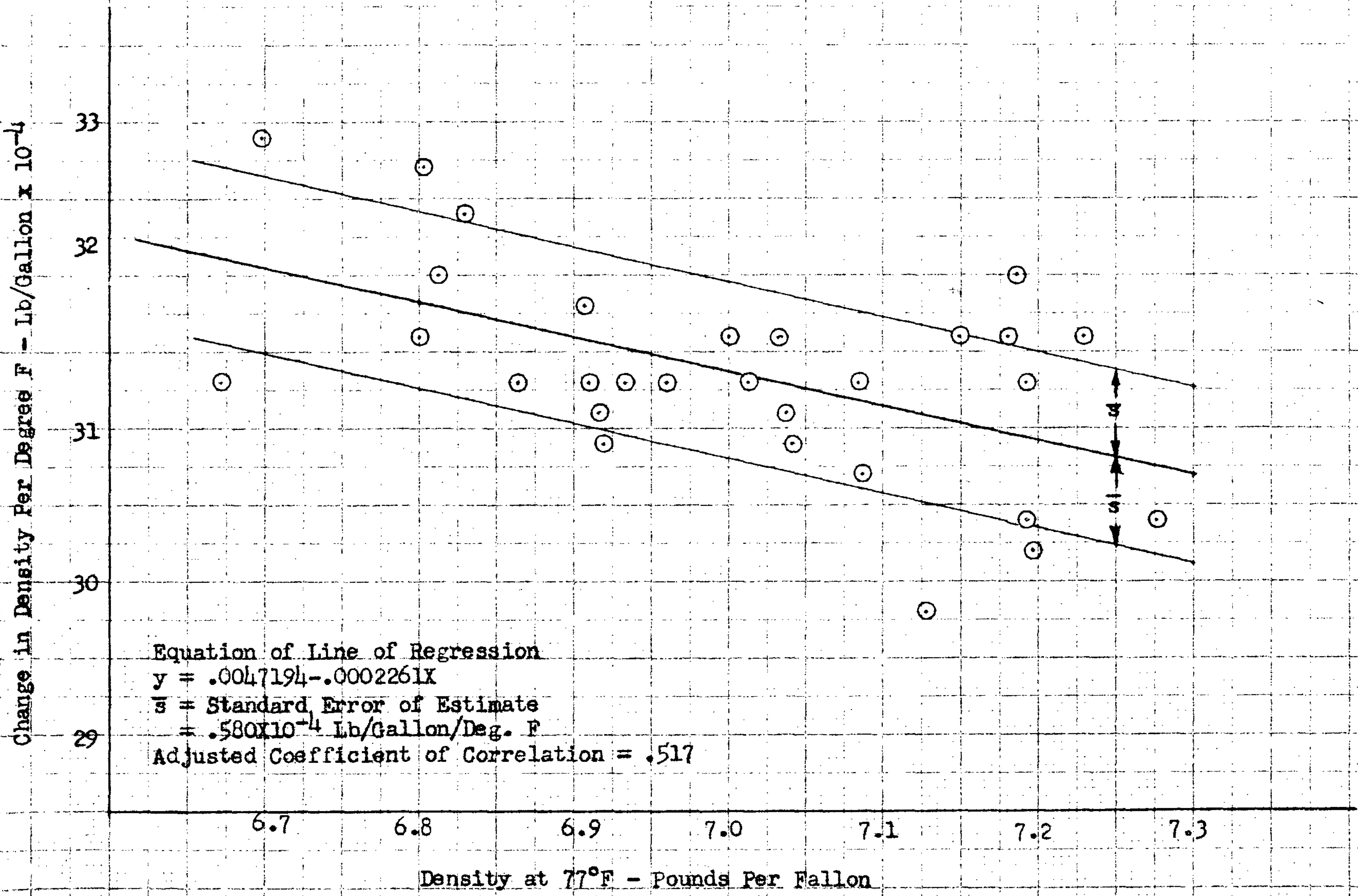


Fig. 37

Slope of Density vs. Temperature Curves as a Function of Density - Diluted New Oils

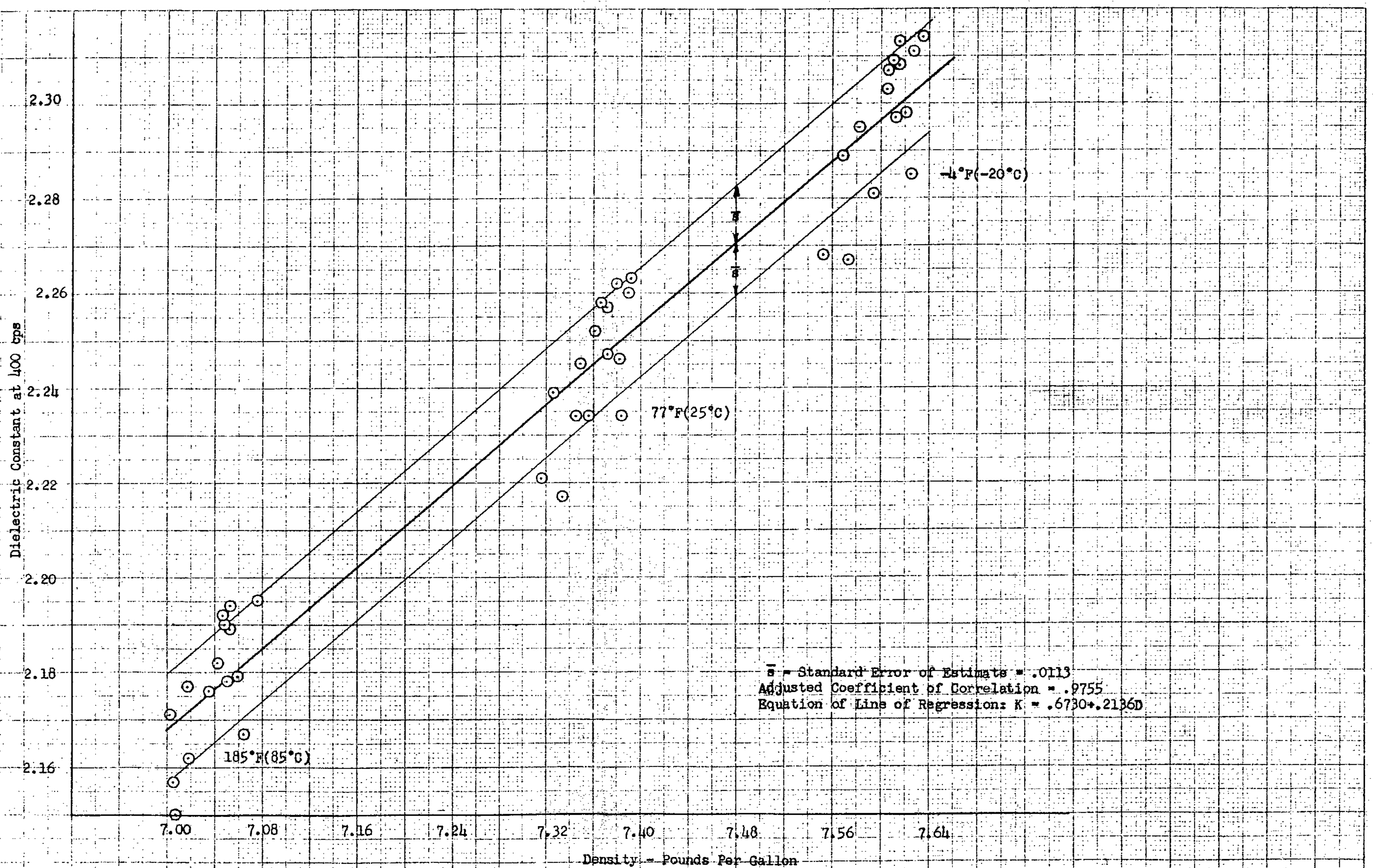


Fig. 38

Grade 1100 New Oil Characteristics at 400 cps

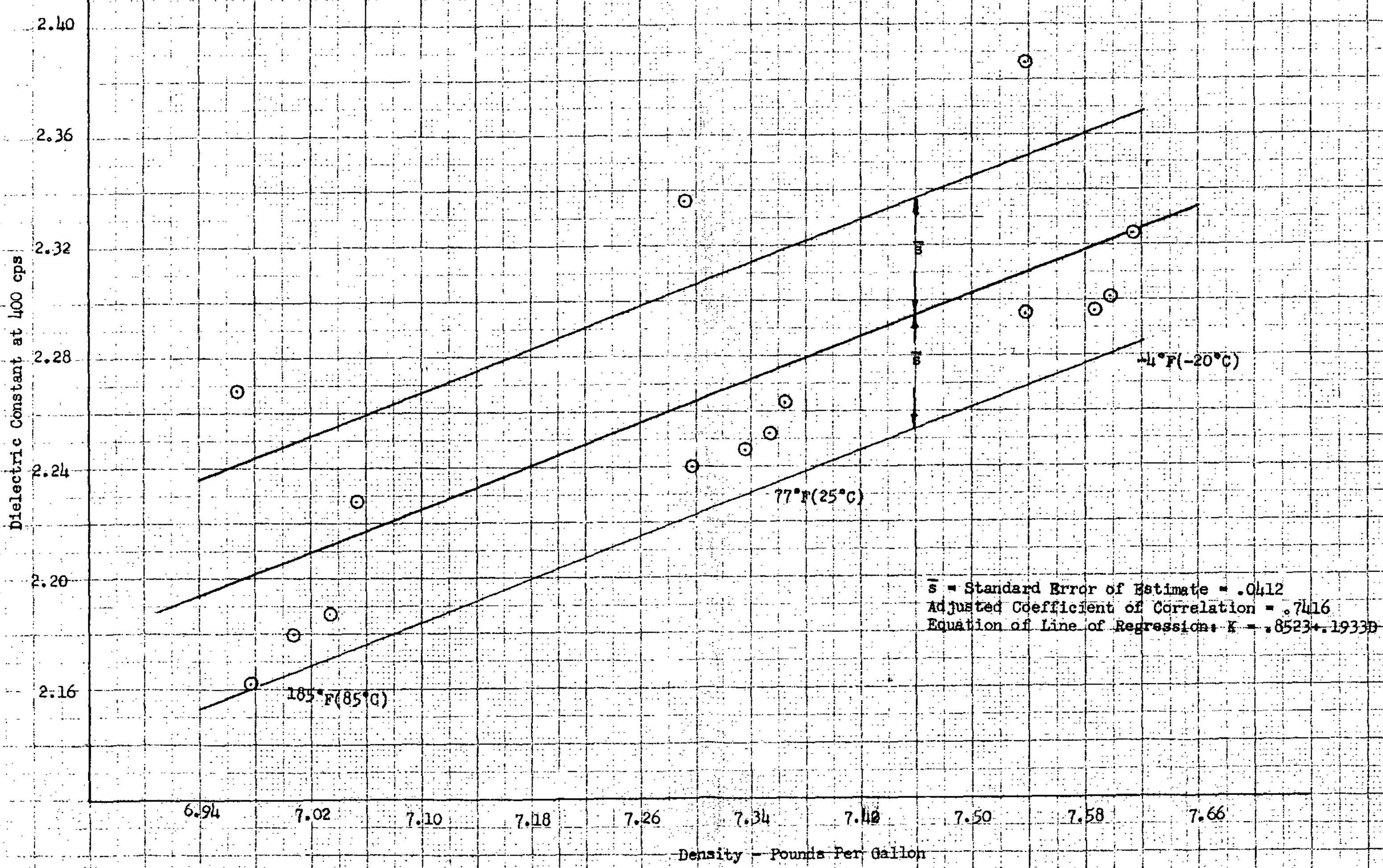


Fig. 39

Grade 1080 New Oil Characteristics at 400 cps

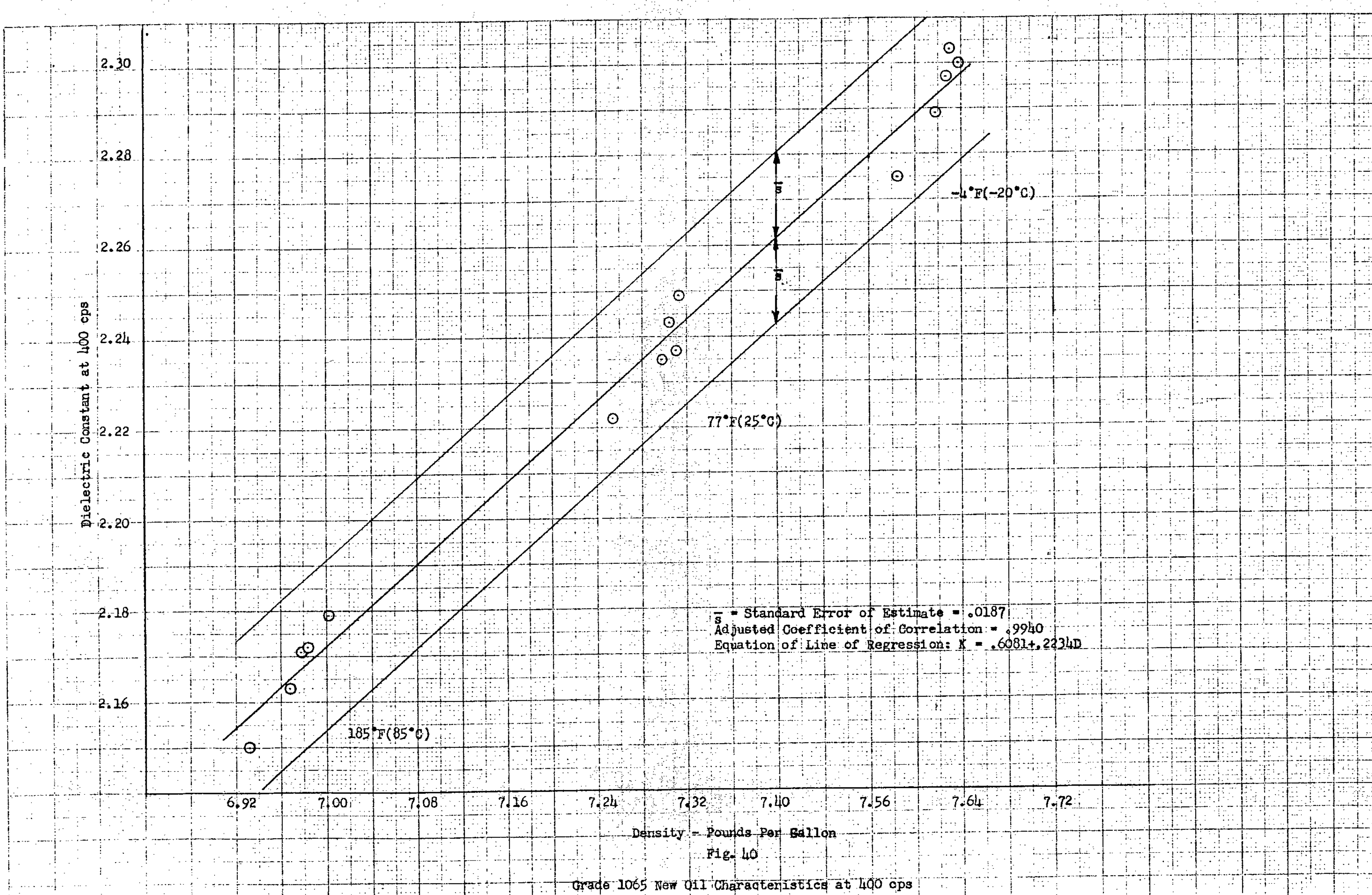


Fig. 40

Grade 1065 New Oil Characteristics at 400 cps

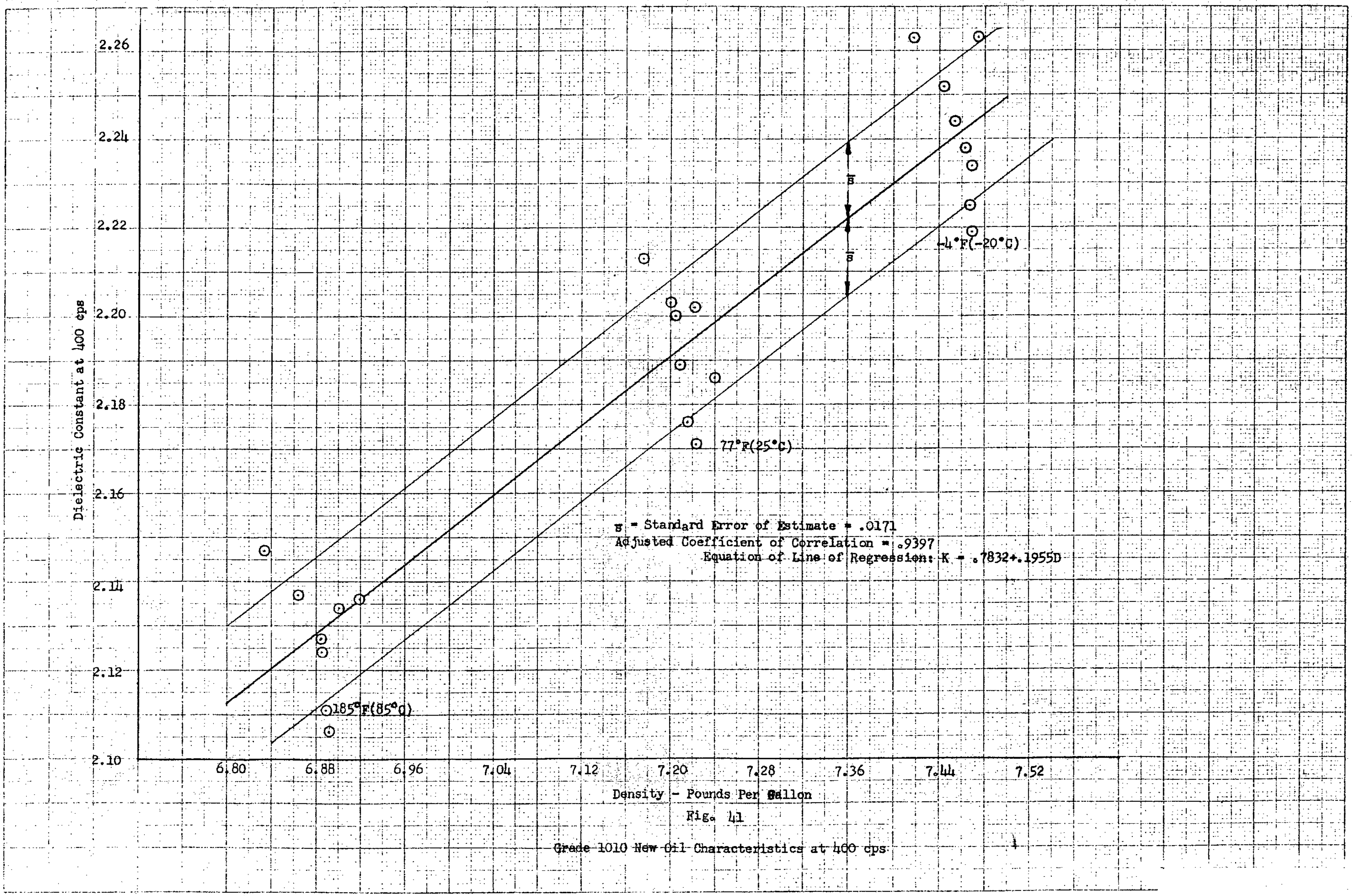


Fig. 41

Grade 1010 New Oil Characteristics at 400 cps

2

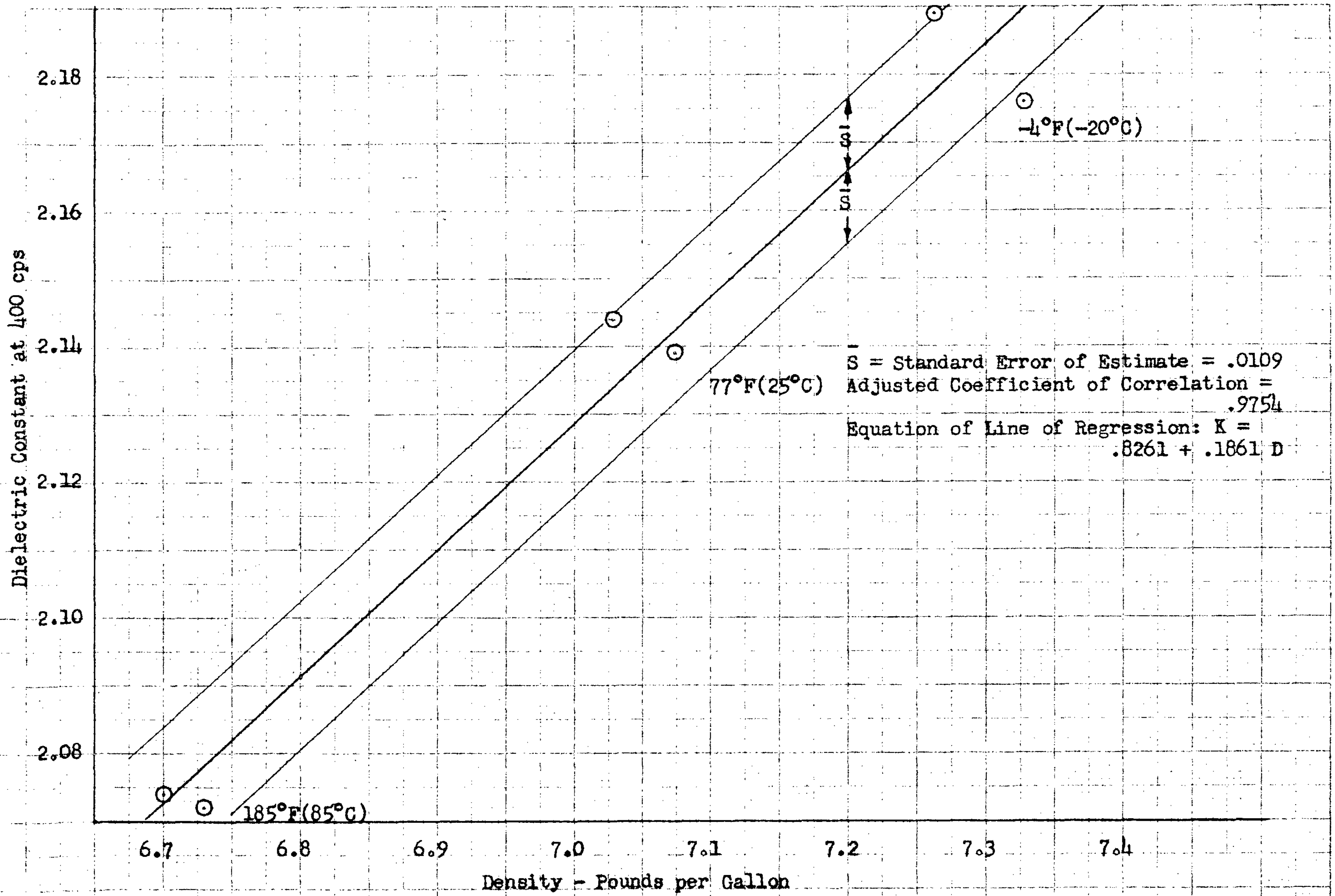


Fig. 42

Grade 1005 New Oil Characteristics at 400 cps

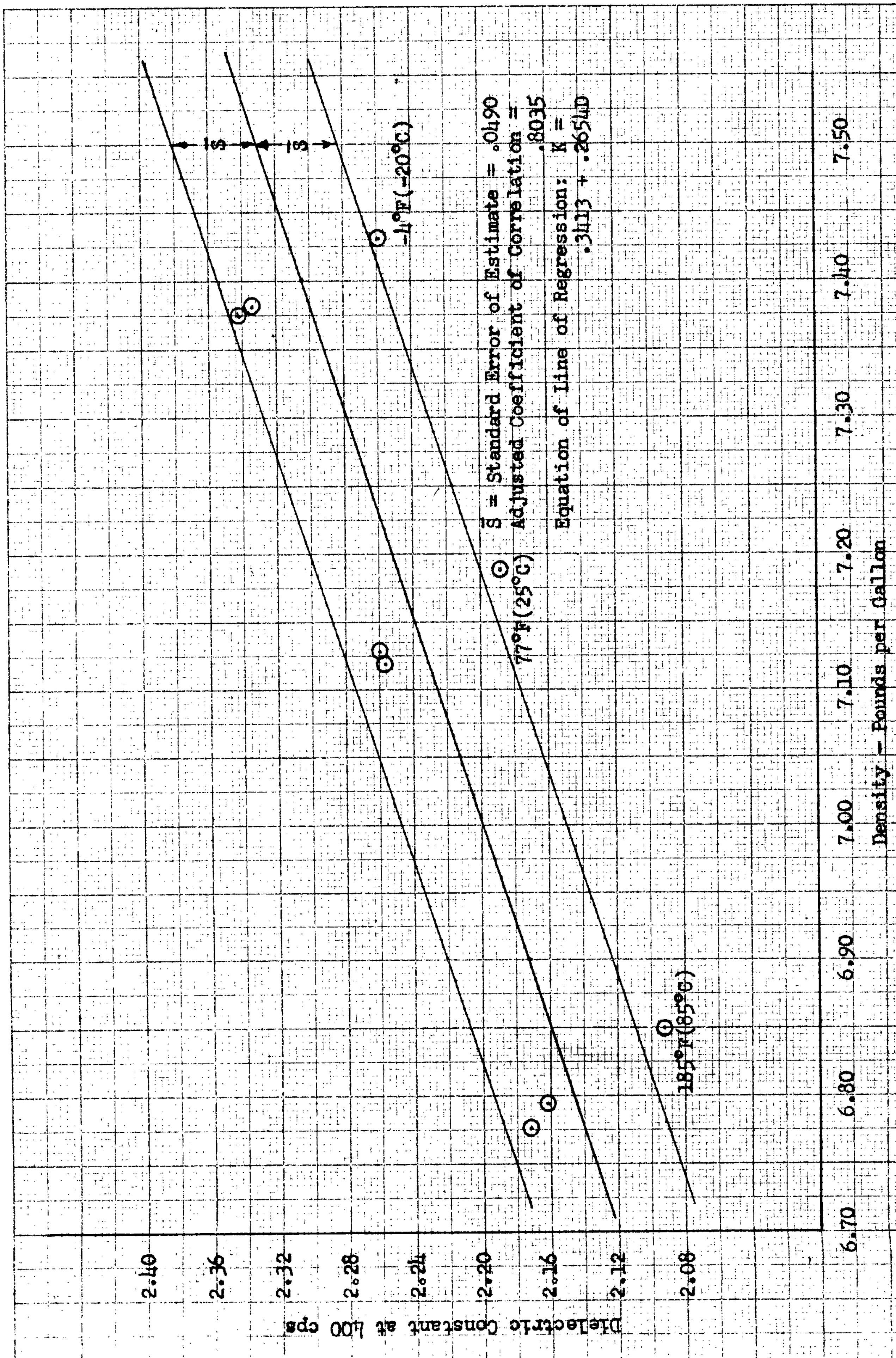


Fig. 43

New Hydraulic Oil Characteristics at 400 cps

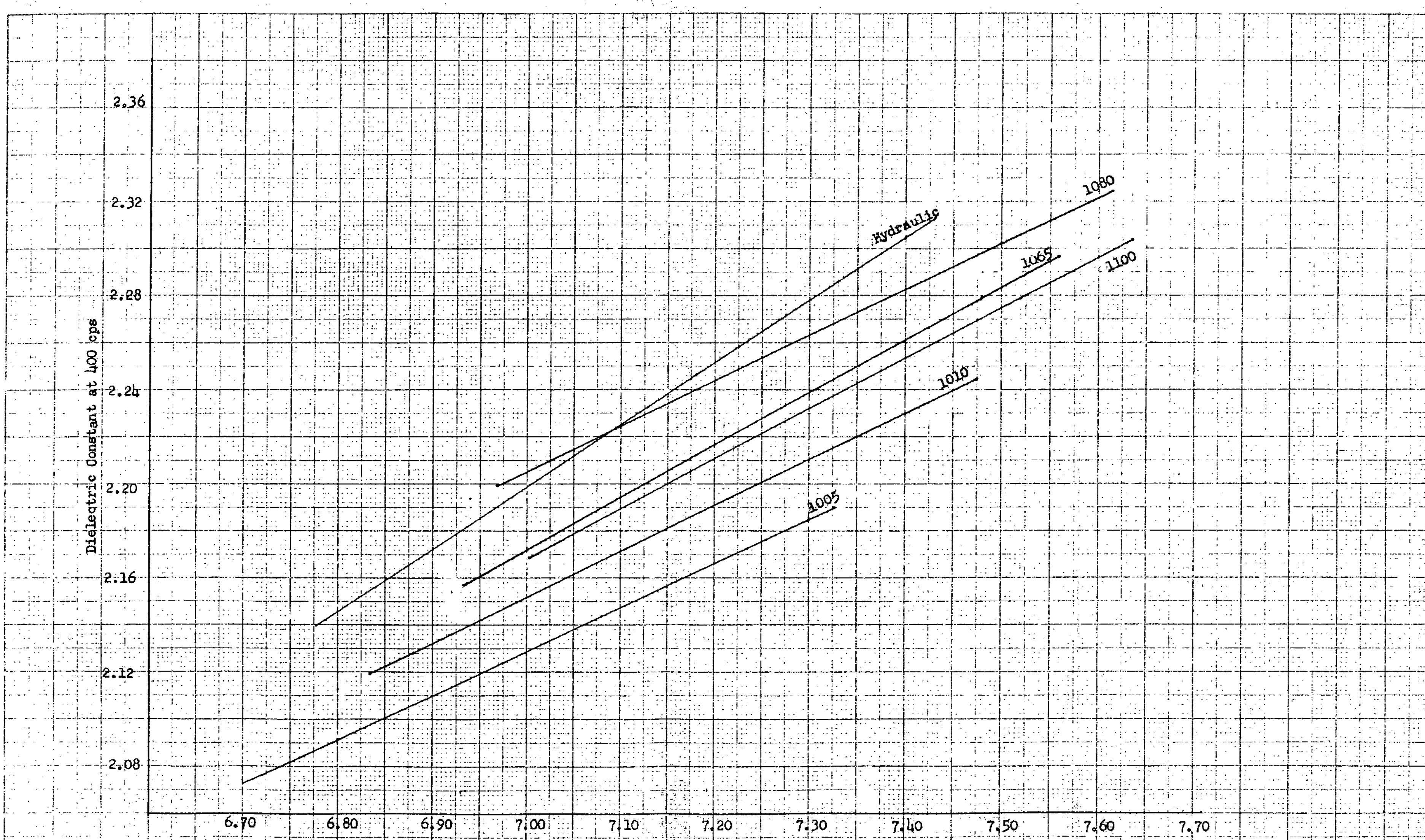


Fig. 44

New Oil Characteristics at 400 cps
-4°F(-20°C) to 185°F(85°)

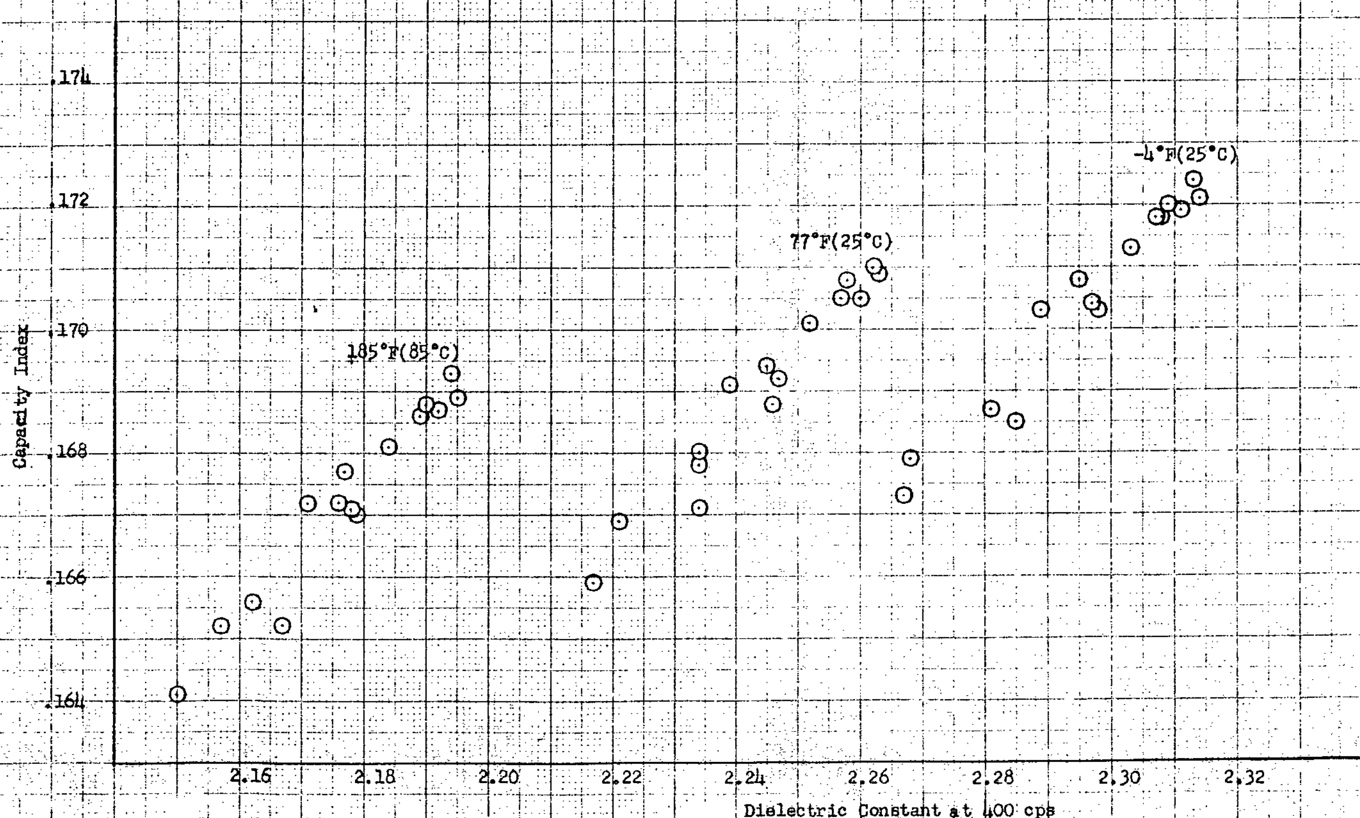


Fig. 45

Grade 1100 New Oil Characteristics

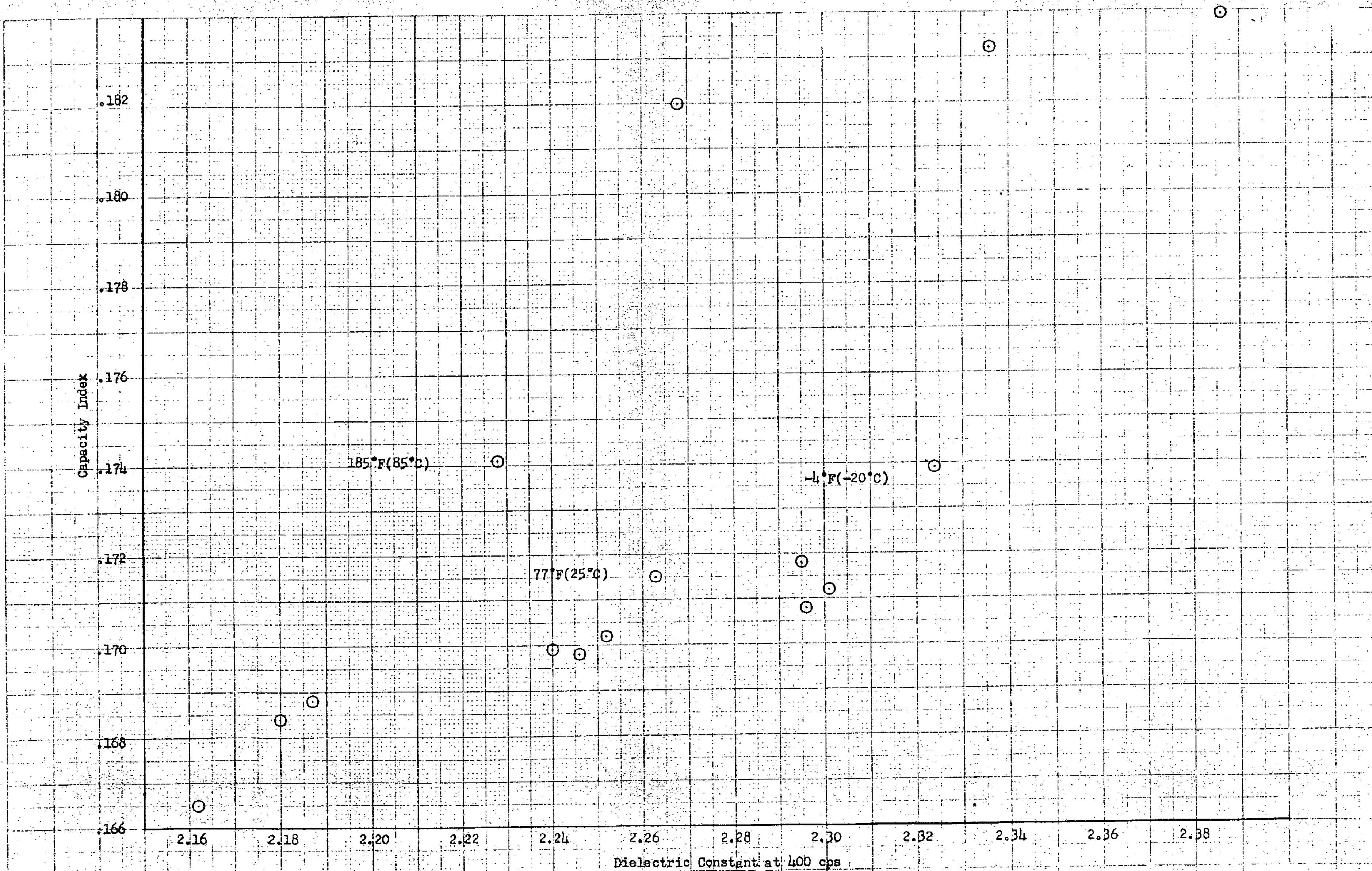
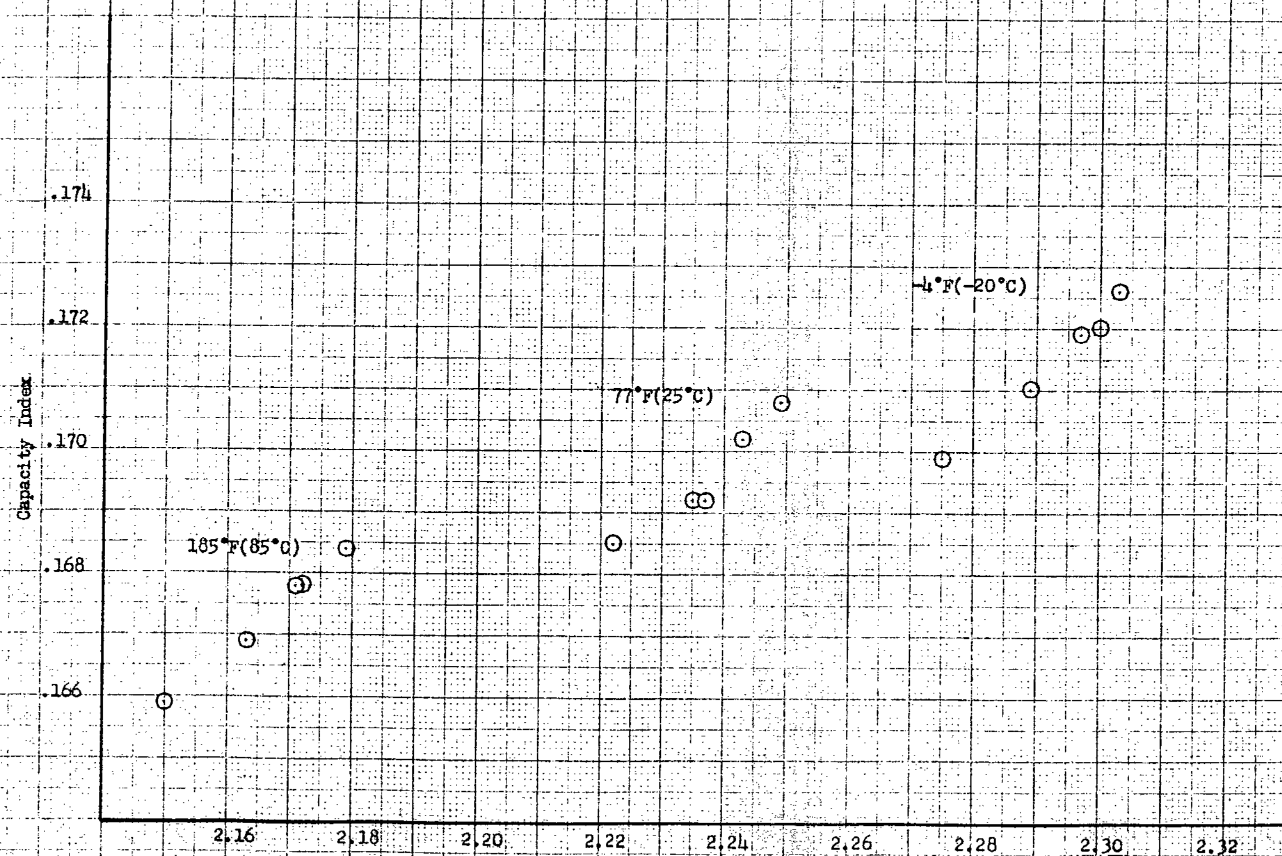


Fig. 46
Grade 1080 New Oil Characteristics



Dielectric Constant at 400 cps

Fig. 47

Grade 1065 New Oil Characteristics

a

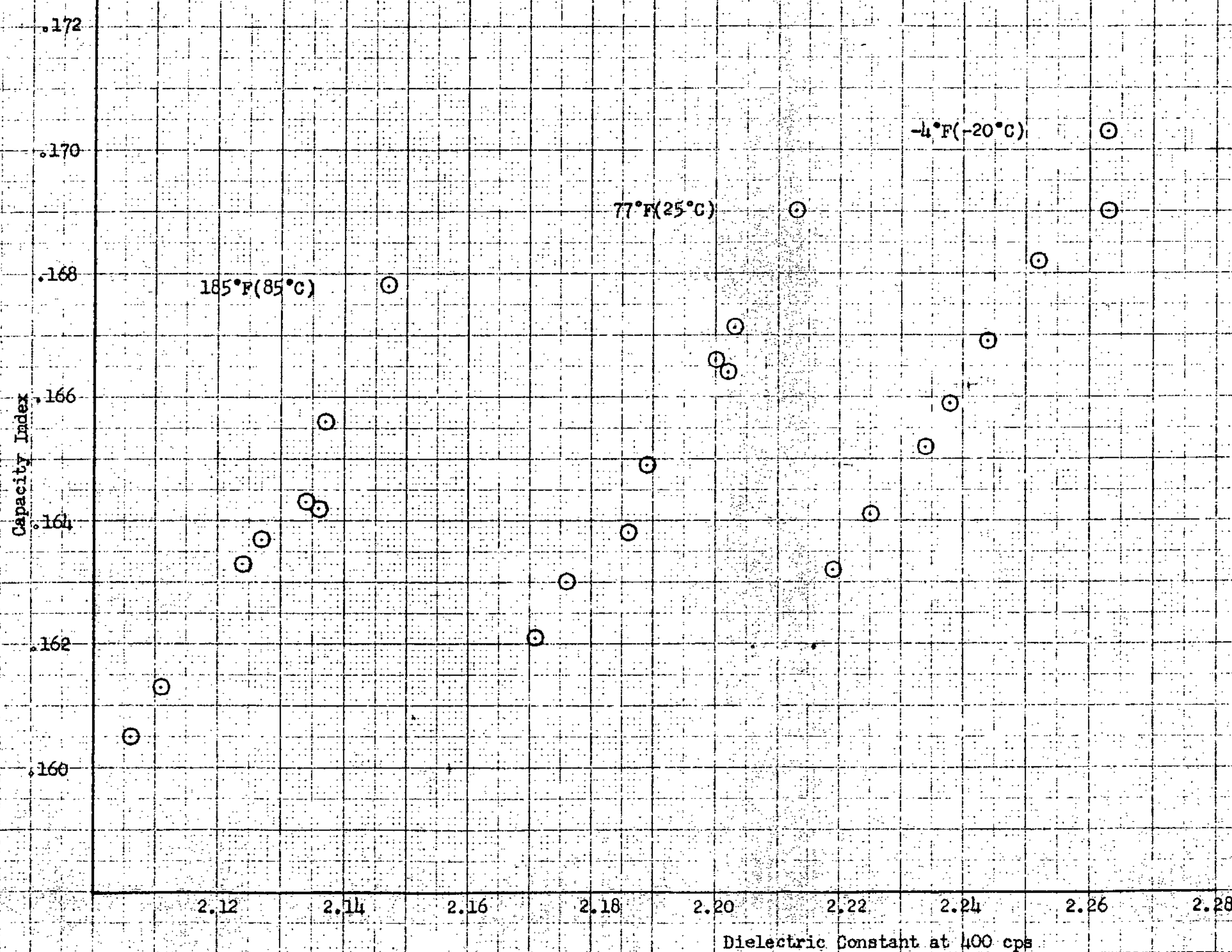


Fig. 48

Grade 1010 New Oil Characteristics

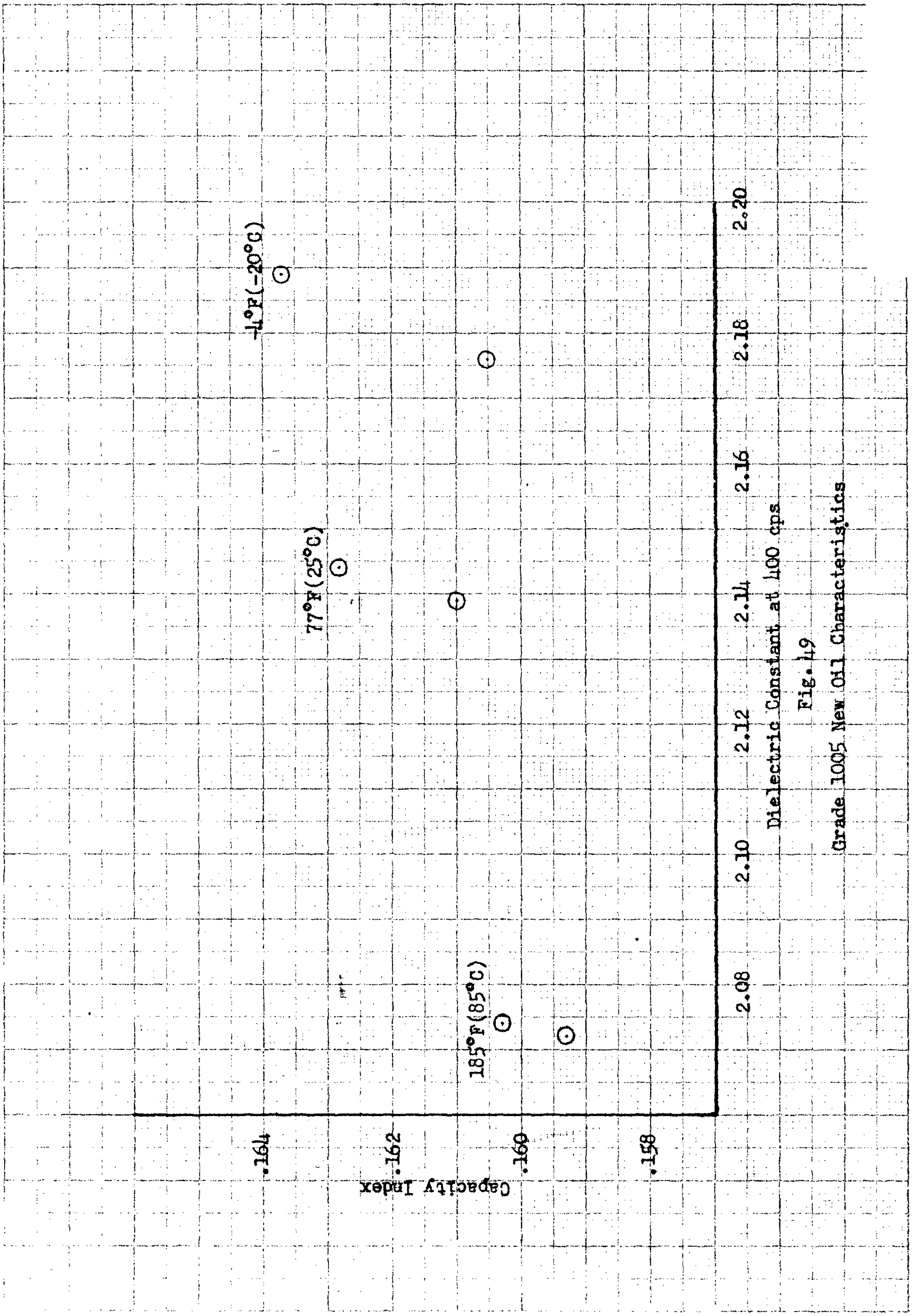


Fig. 49

Grade 1005 New Oil Characteristics

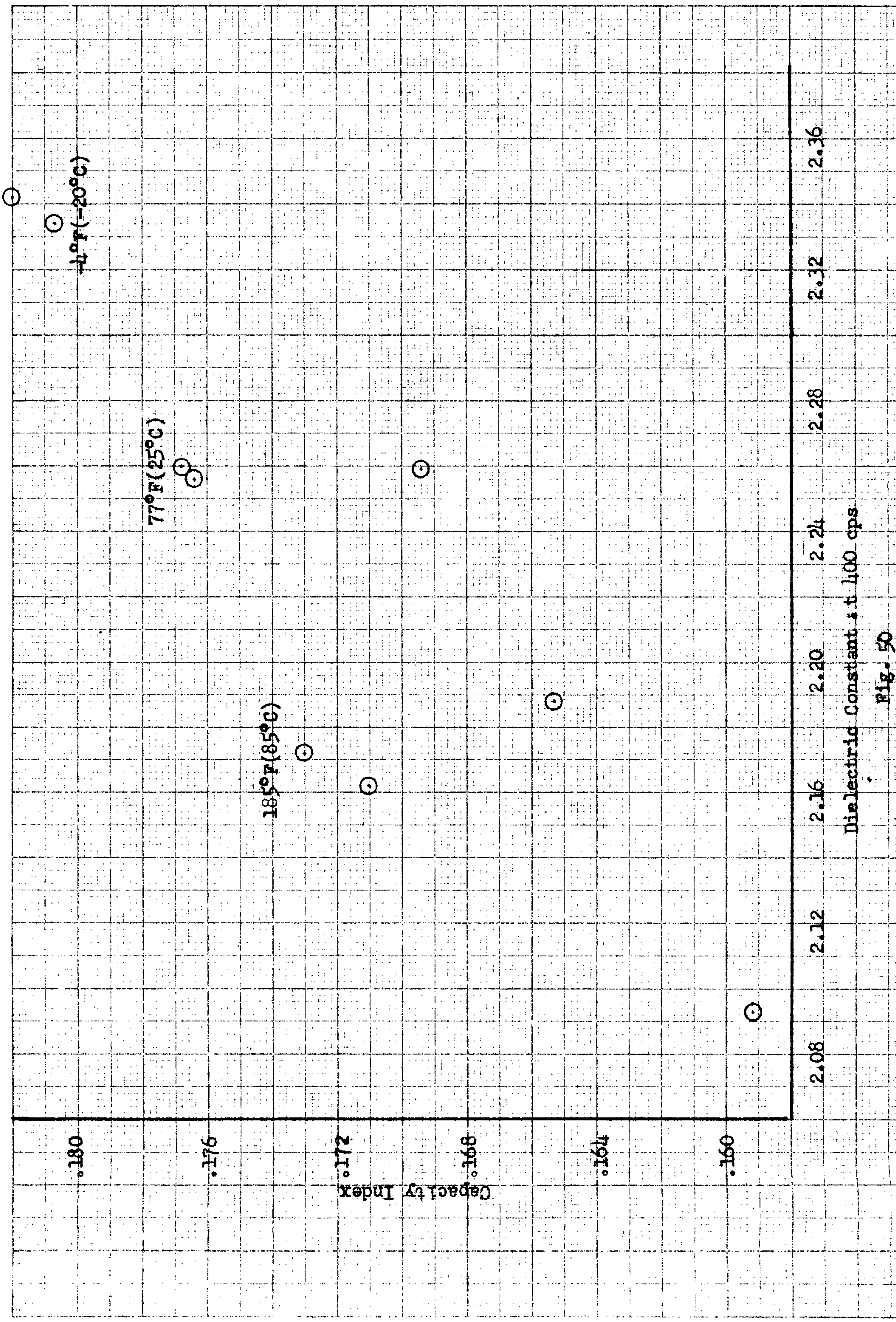


Fig. 50
New Hydraulic Oil Characteristics

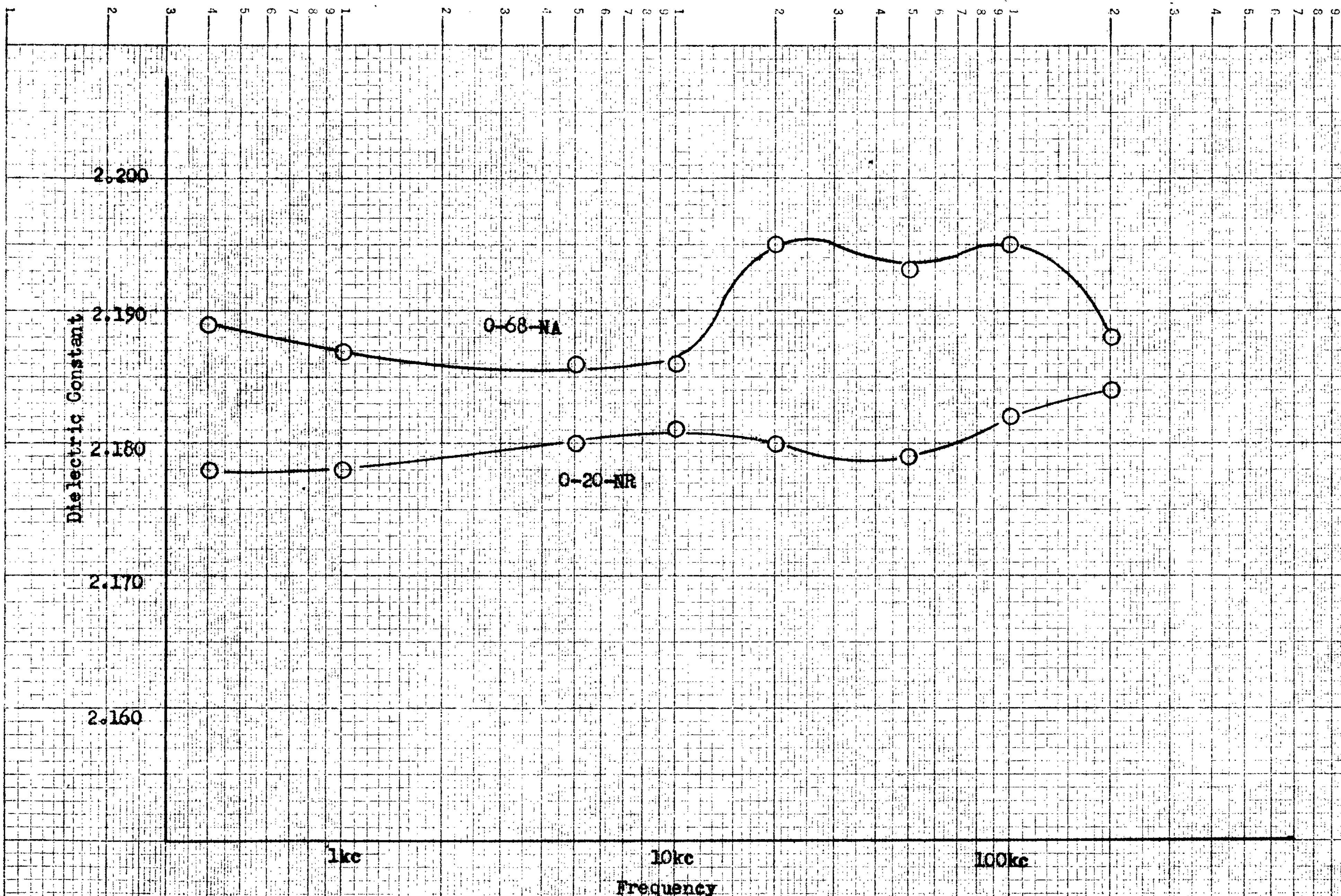
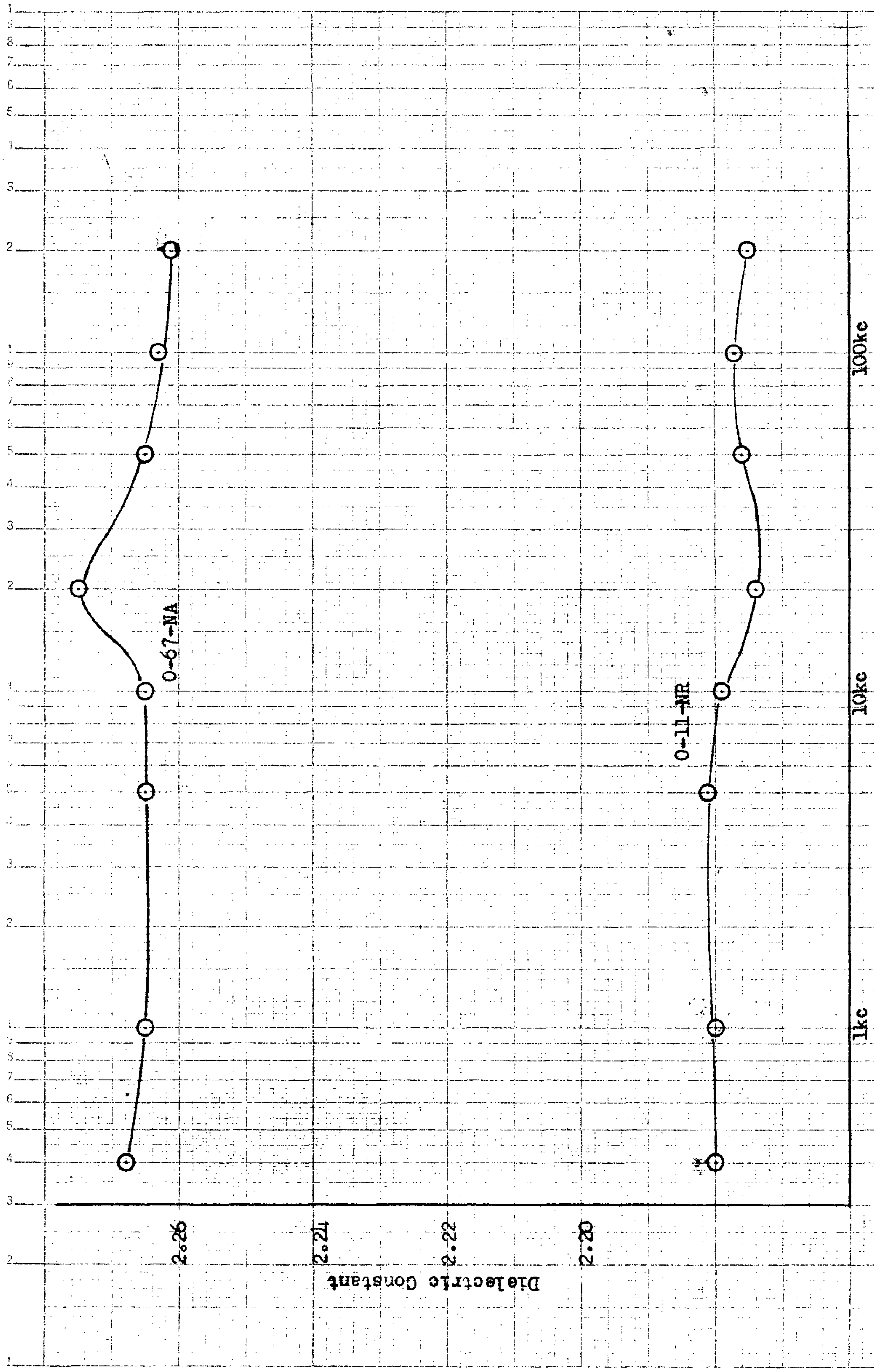


Fig. 51

Dielectric Constant vs. Frequency at 185°F(85°C)
Grade 1100 New Oil



Frequency

Fig. 52

Dielectric Constant vs. Frequency at 185°F(85°C)
Grade 1080 New Oil

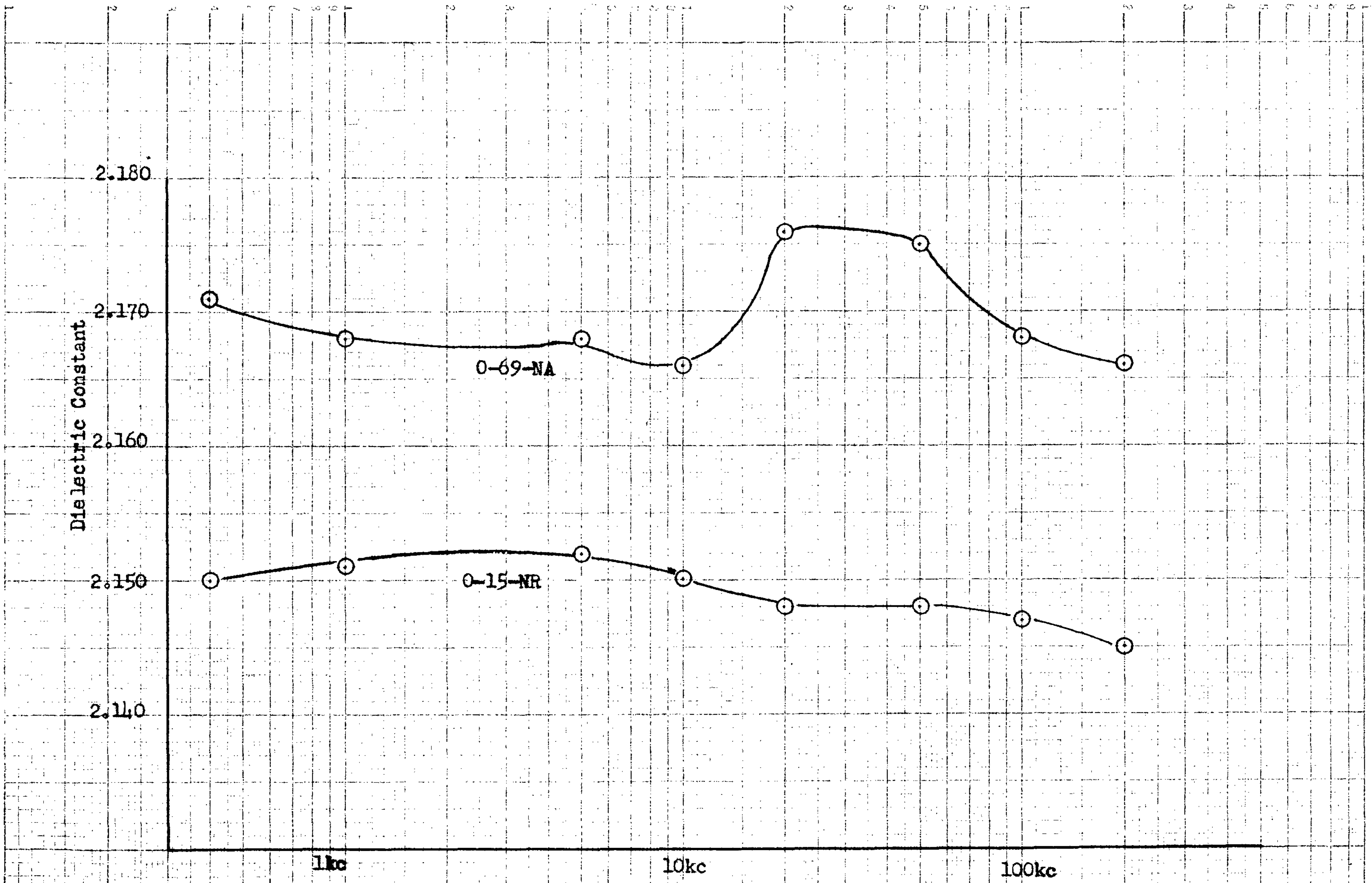


Fig. 53

Dielectric Constant vs. Frequency at 185°F(85°C)
Grade 1065 New Oil

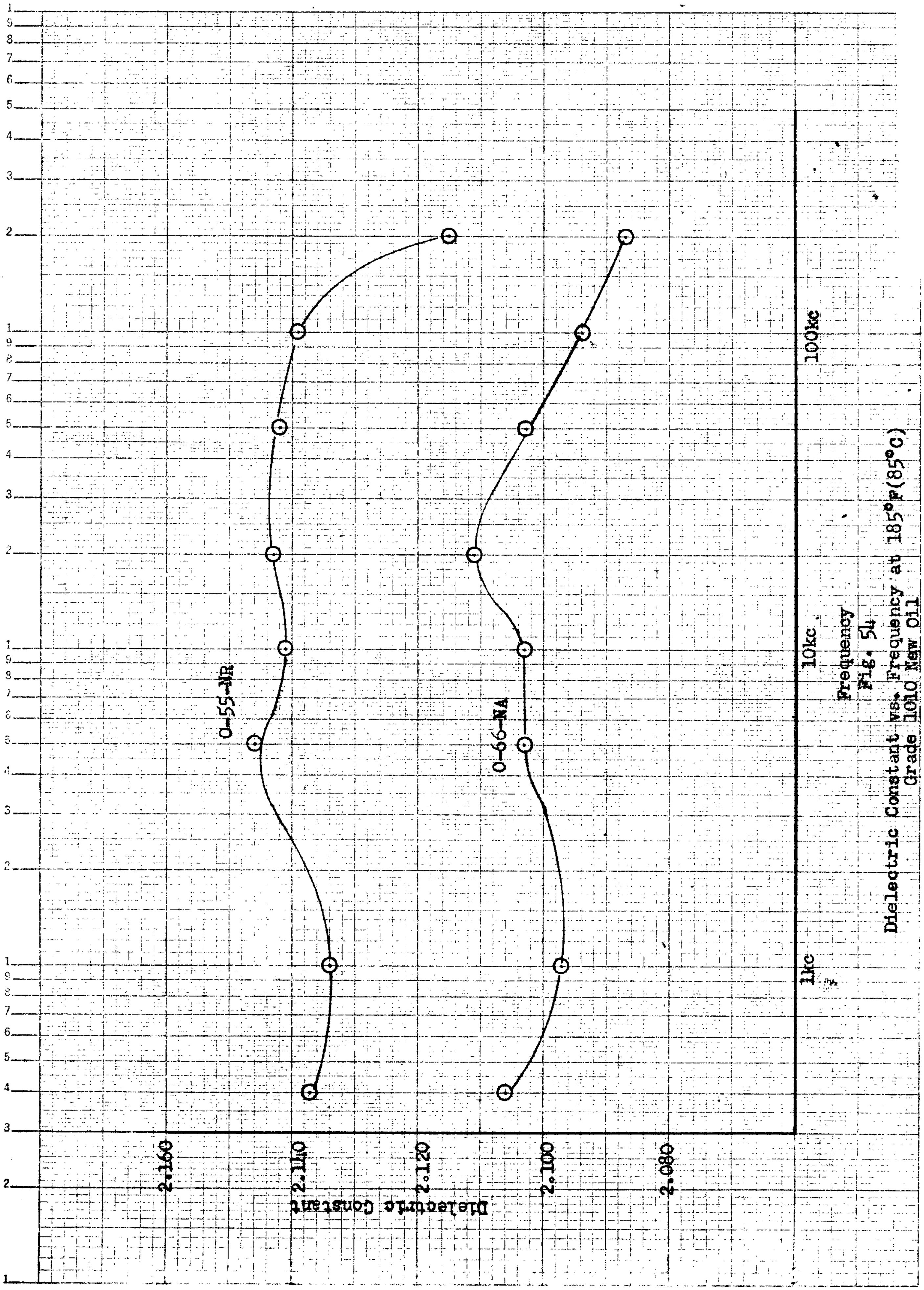


Fig. 54
Dielectric Constant vs. Frequency at 185°F(85°C)
Grade 1010 New Oil

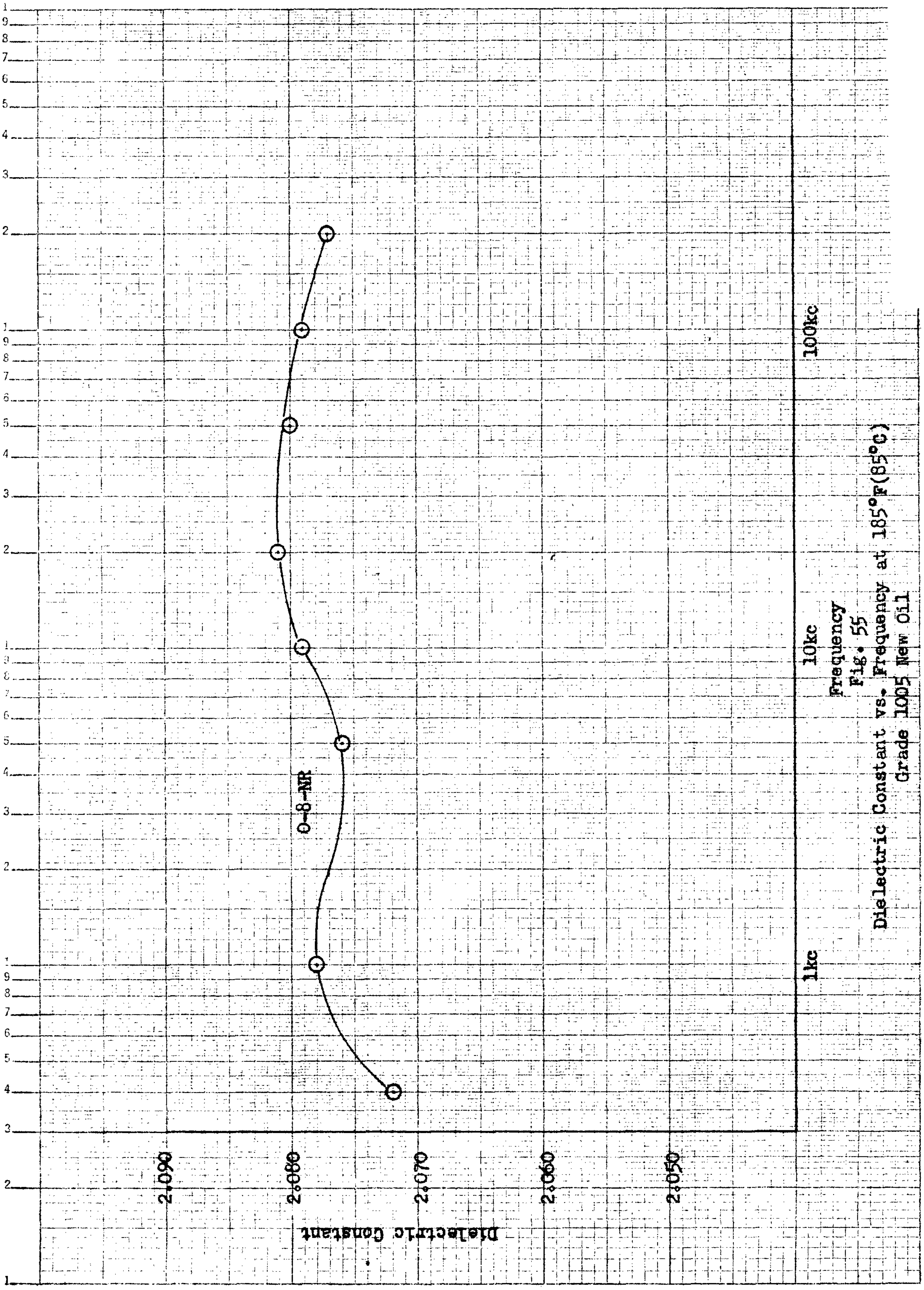


Fig. 55
Dielectric Constant vs. Frequency at 185°F(85°C)
Grade 1005 New Oil

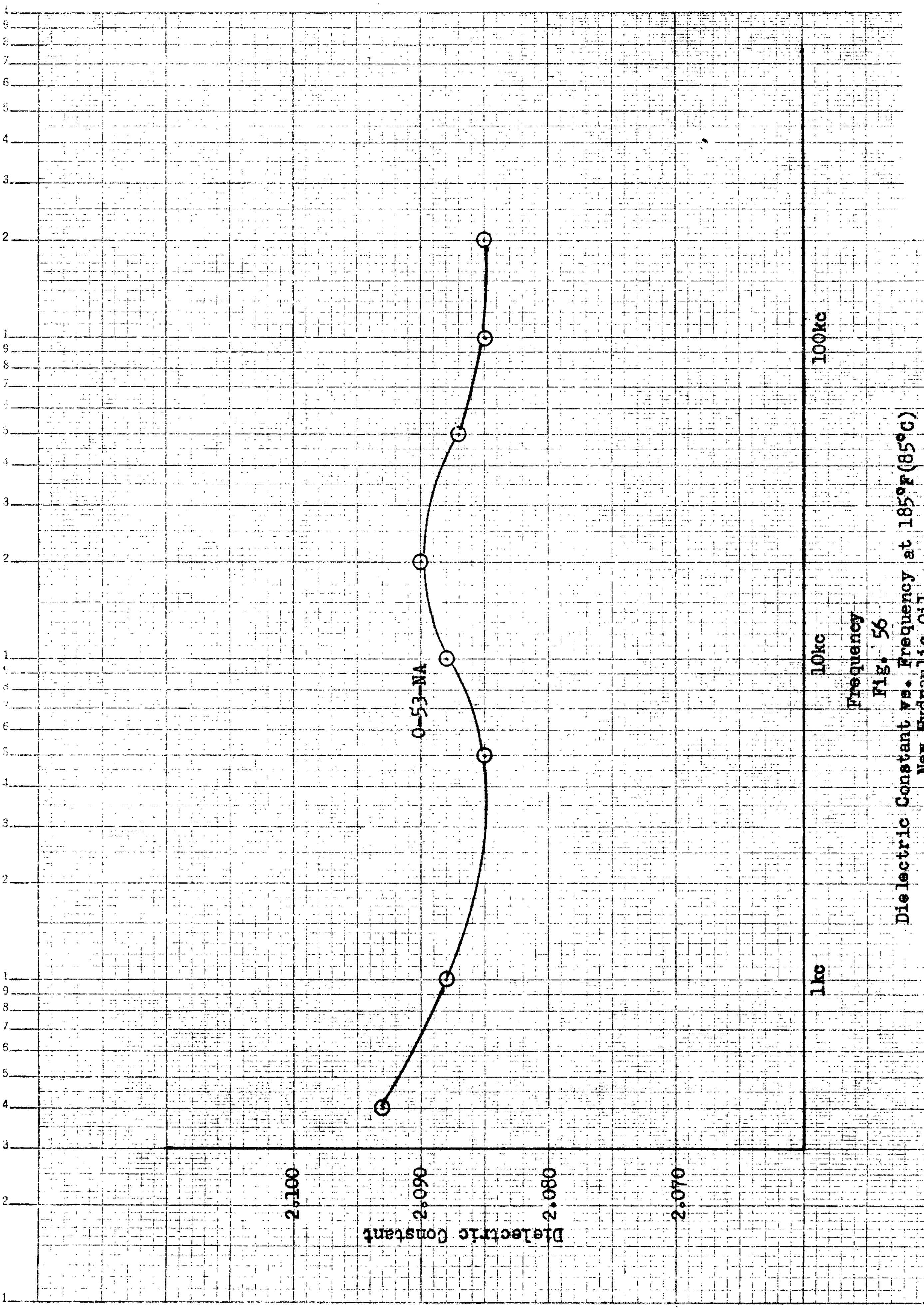
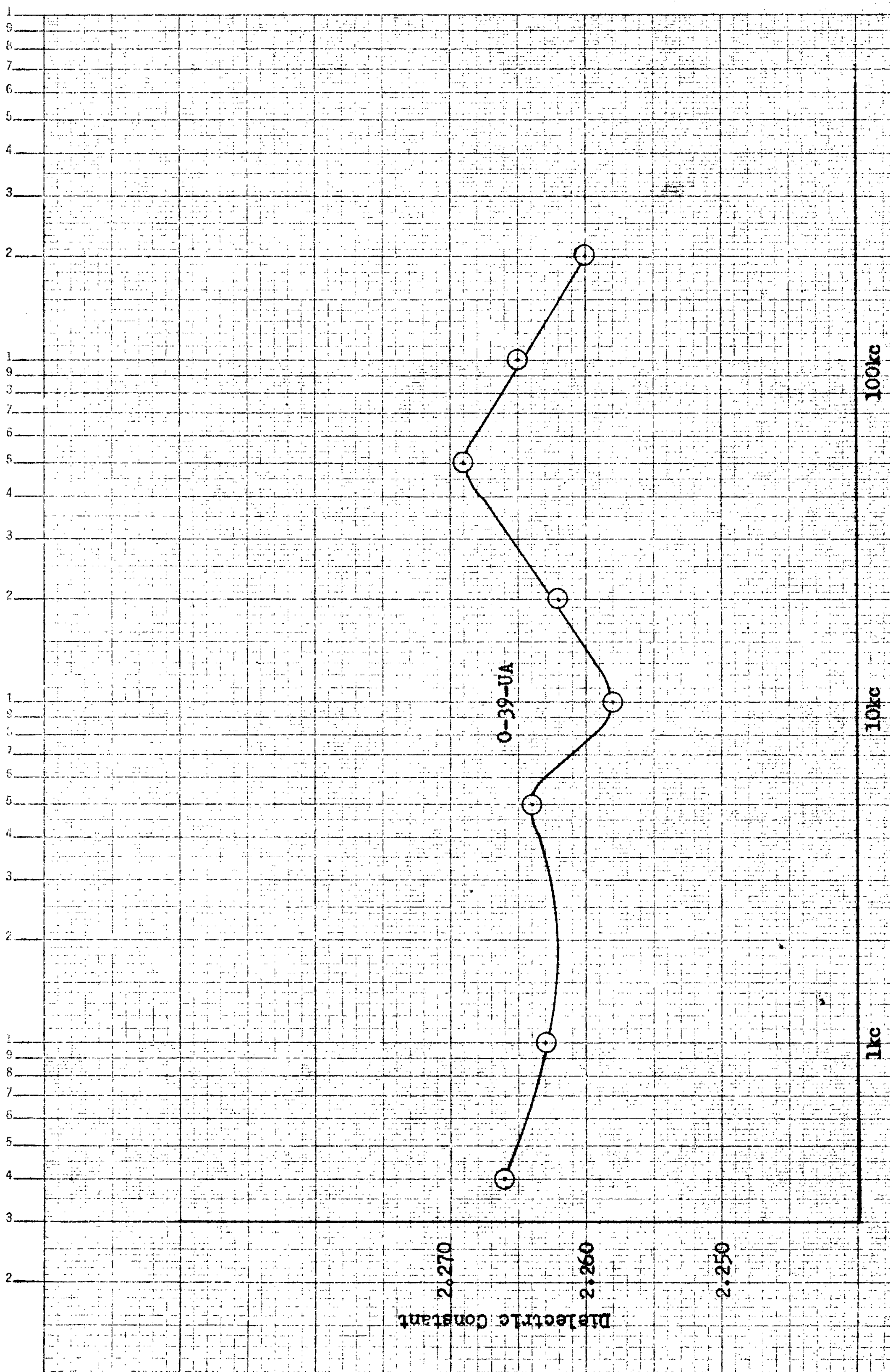


Fig. 56
Dielectric Constant vs. Frequency at 185°F (85°C)
New Hydraulic Oil



Frequency

Fig. 57

Dielectric Constant vs. Frequency at 185°F(85°C)
Grade 1100 Used Oil

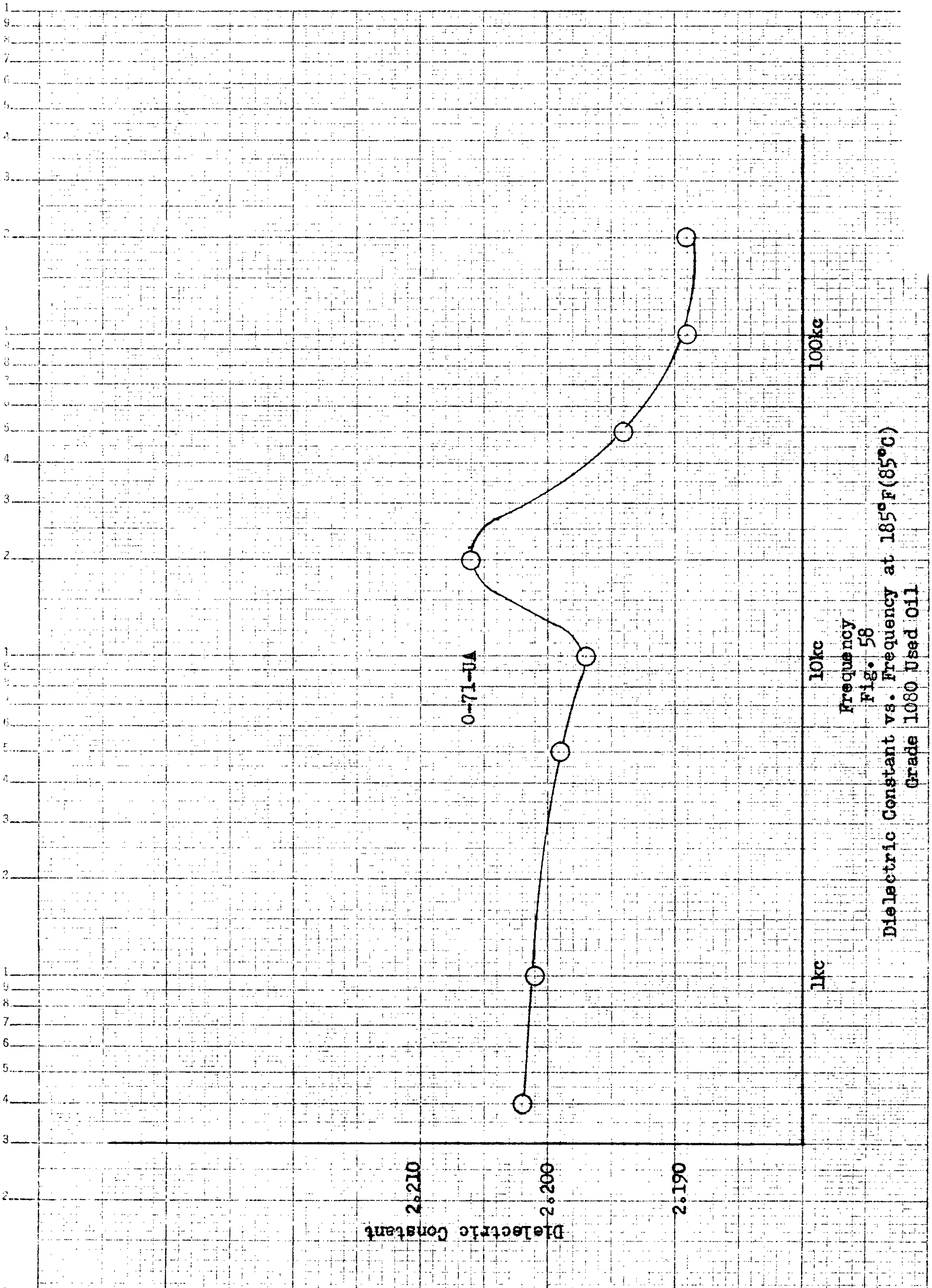
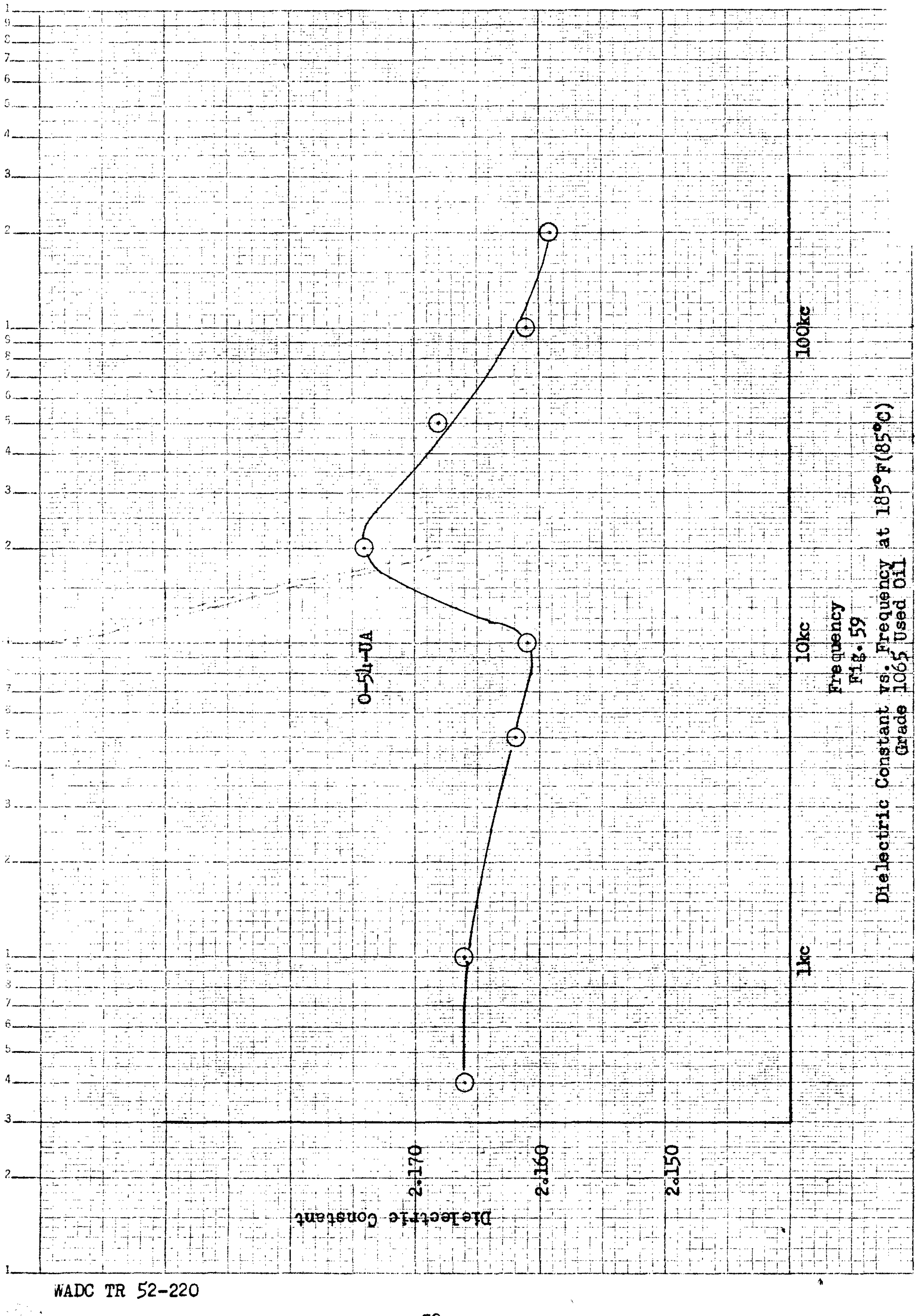


Fig. 58
Dielectric Constant vs. Frequency at 185°F (85°C)
Grade 1080 Used Oil



Frequency
Fig. 59
Dielectric Constant vs. Frequency at 185°F(85°C)
Grade 1065 Used Oil

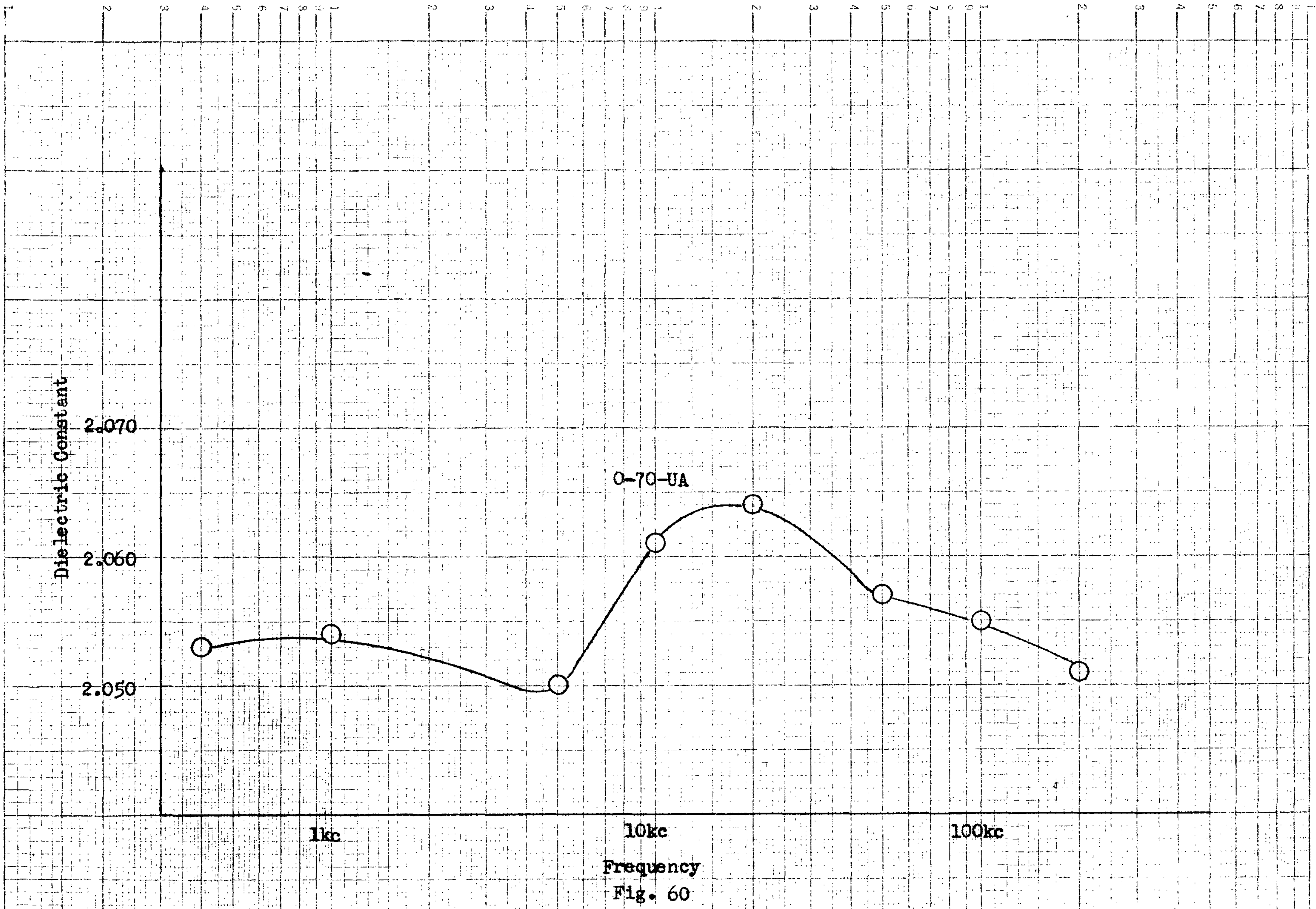


Fig. 60

Dielectric Constant vs. Frequency at 185°F(85°C)
Grade 1010 Used Oil

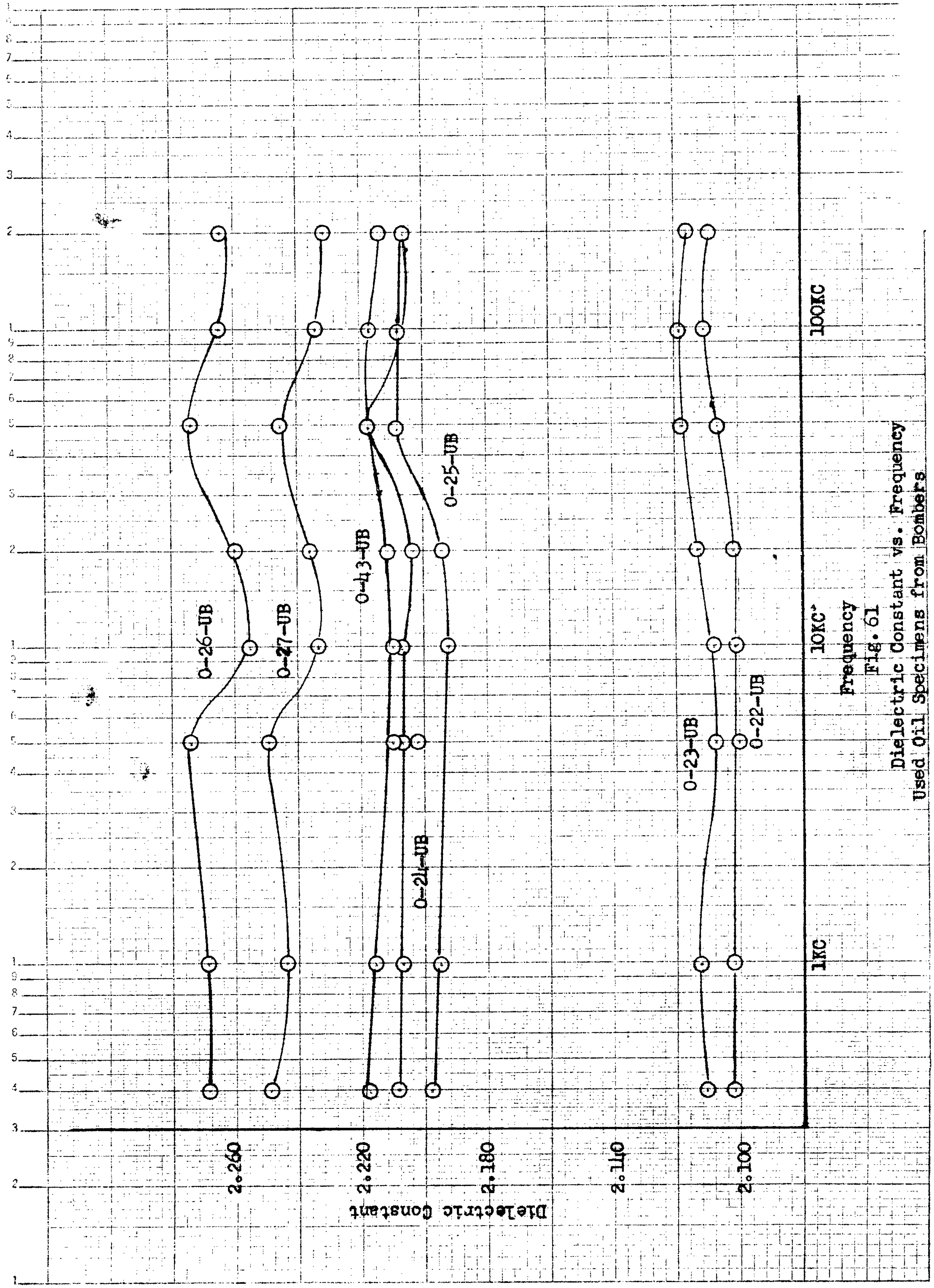


Fig. 61
Dielectric Constant vs. Frequency
Used Oil Specimens from Bombers

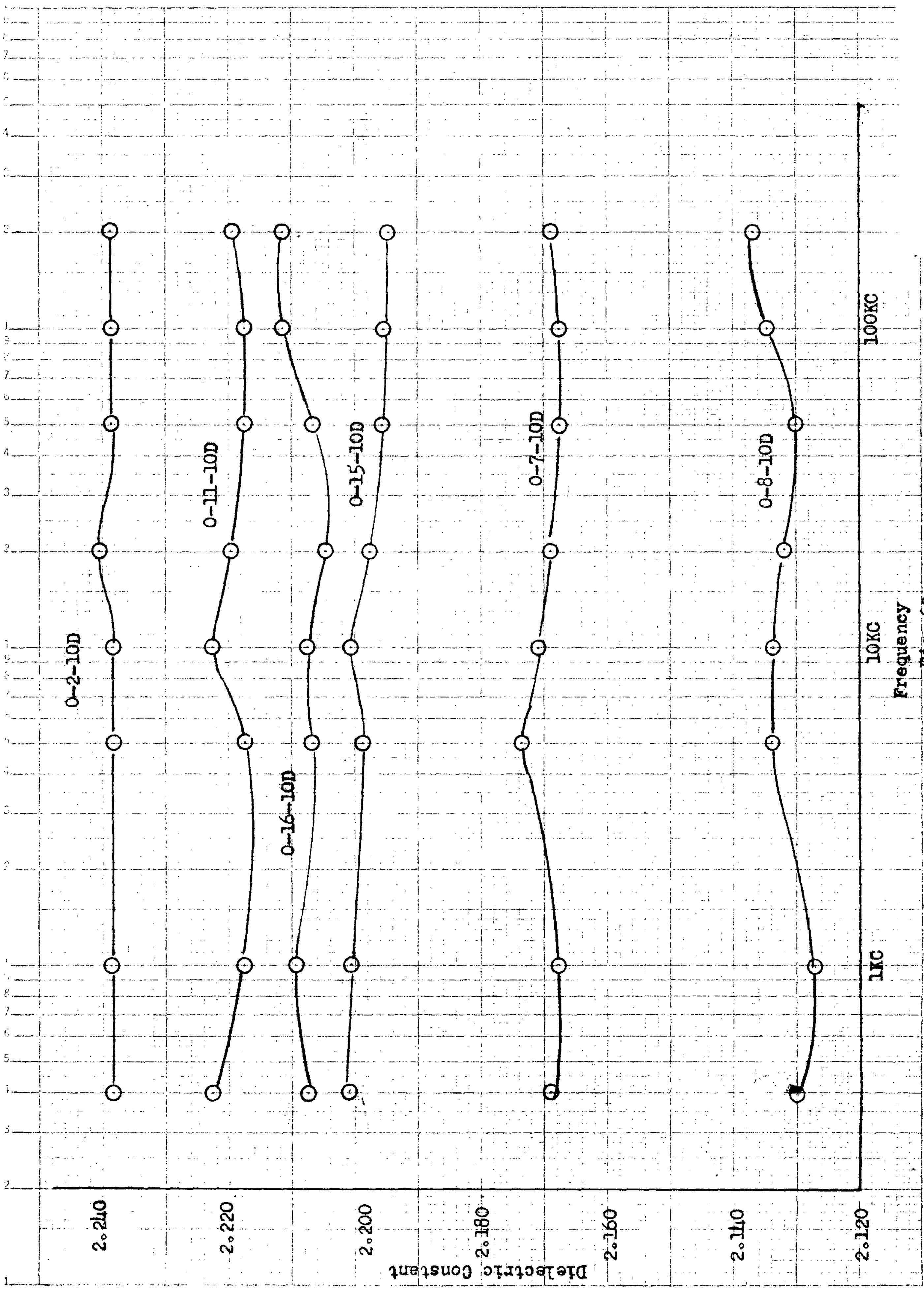


Fig. 62
Dielectric Constant vs. Frequency
10% Diluted Specimens

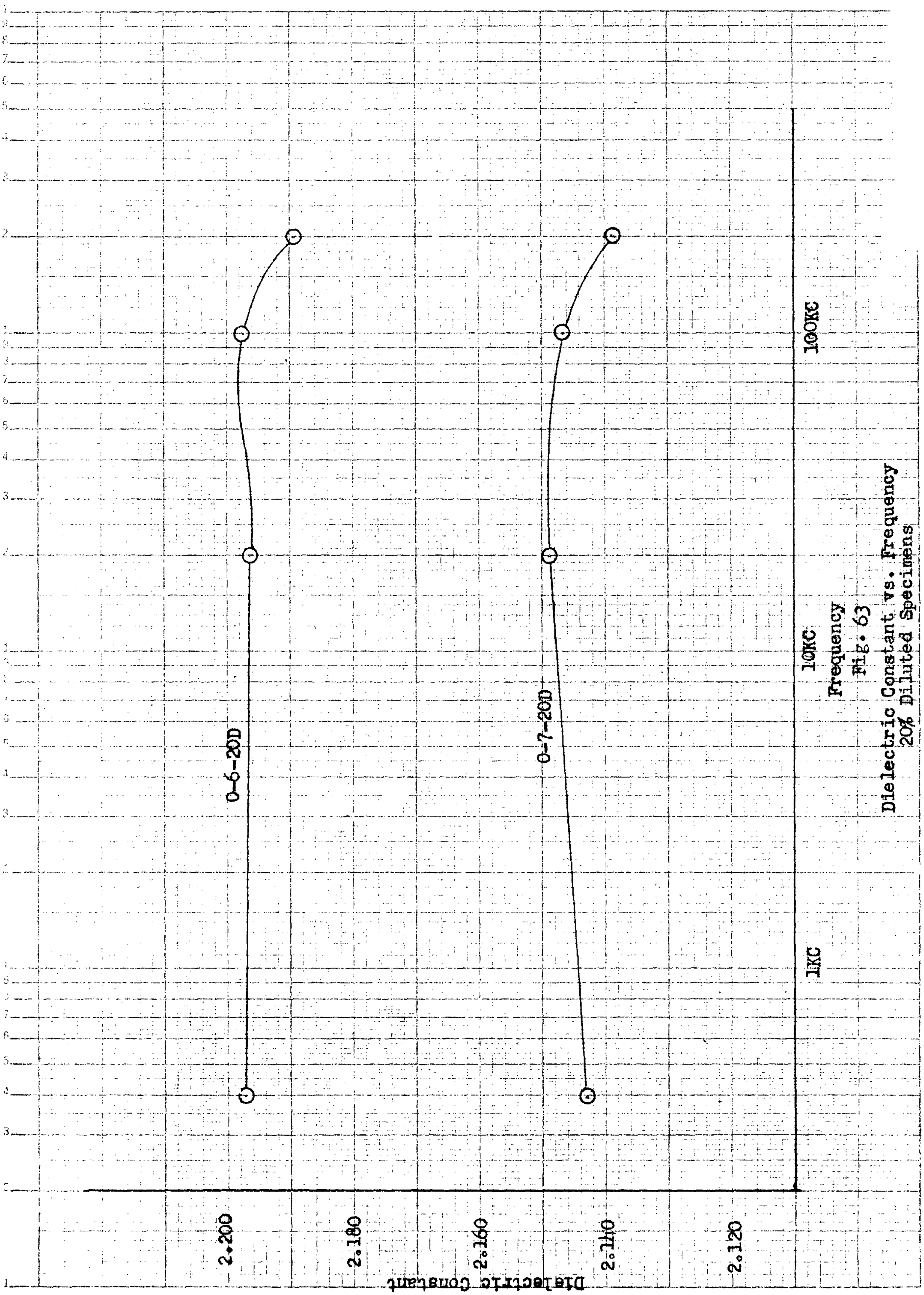


Fig. 63
Dielectric Constant vs. Frequency
20% Diluted Specimens

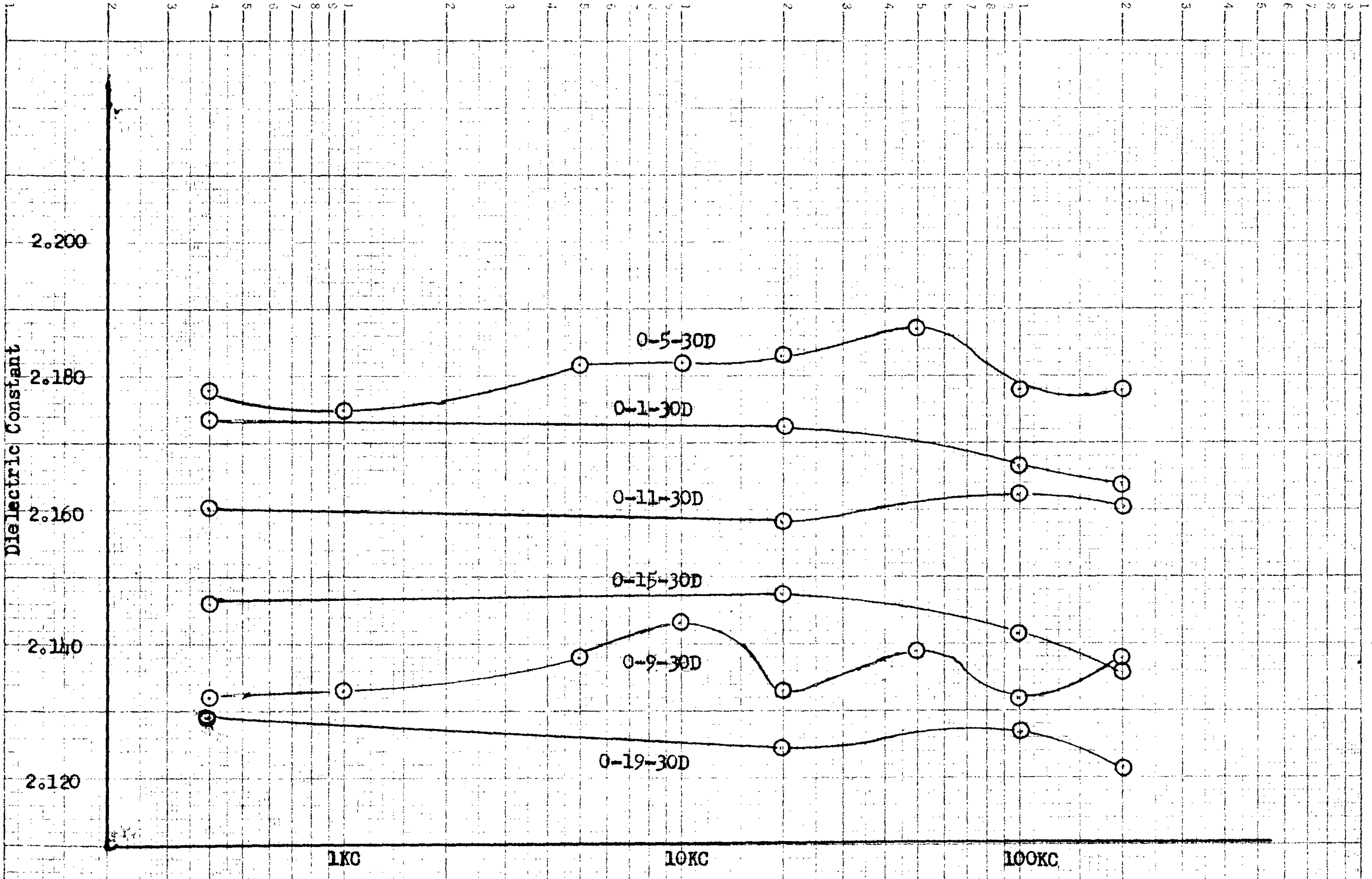


Fig. 64

Dielectric Constant vs. Frequency
30% Diluted Specimens

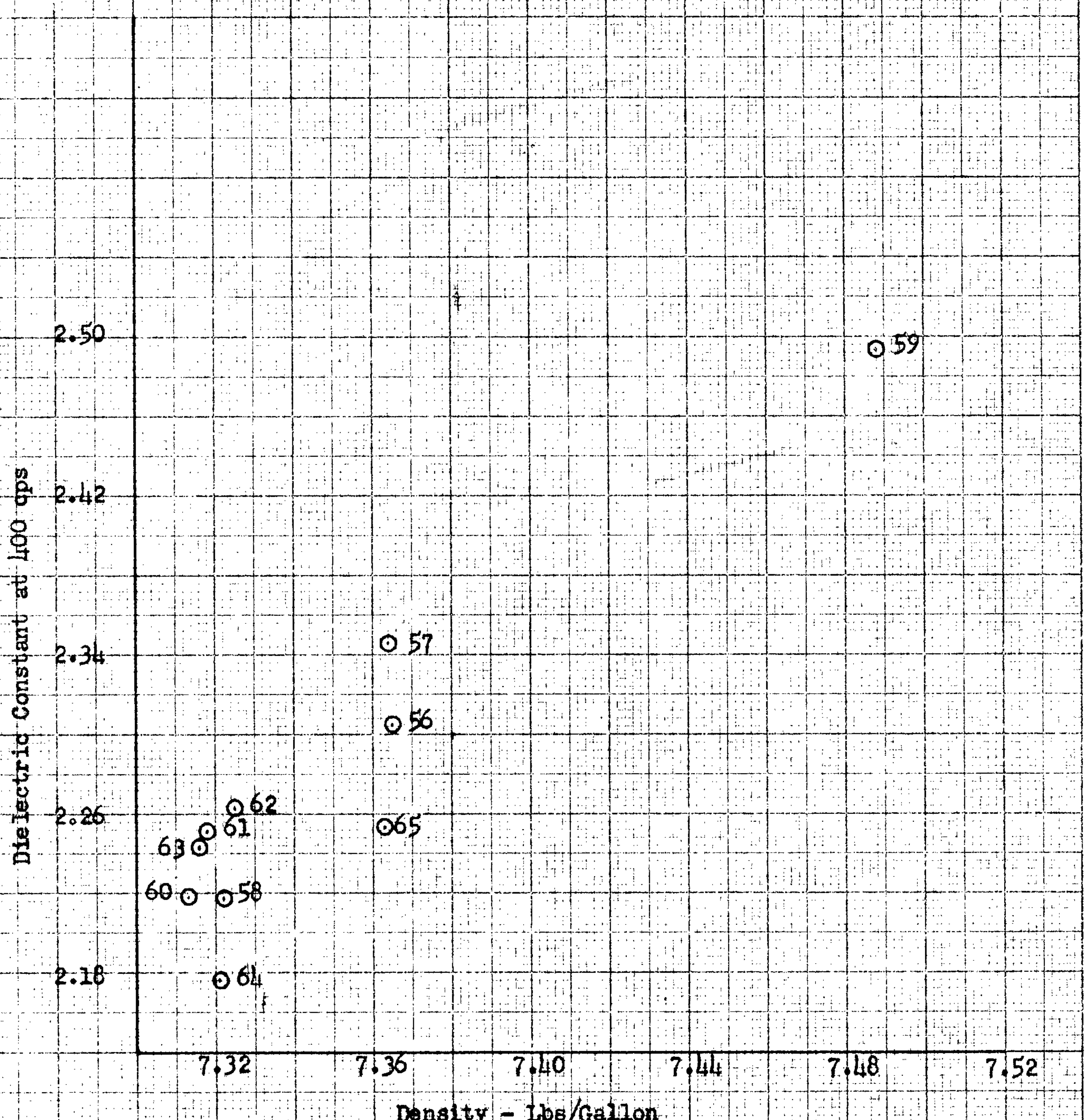


Fig. 65

Effect of Additives at 77°F(25°C)

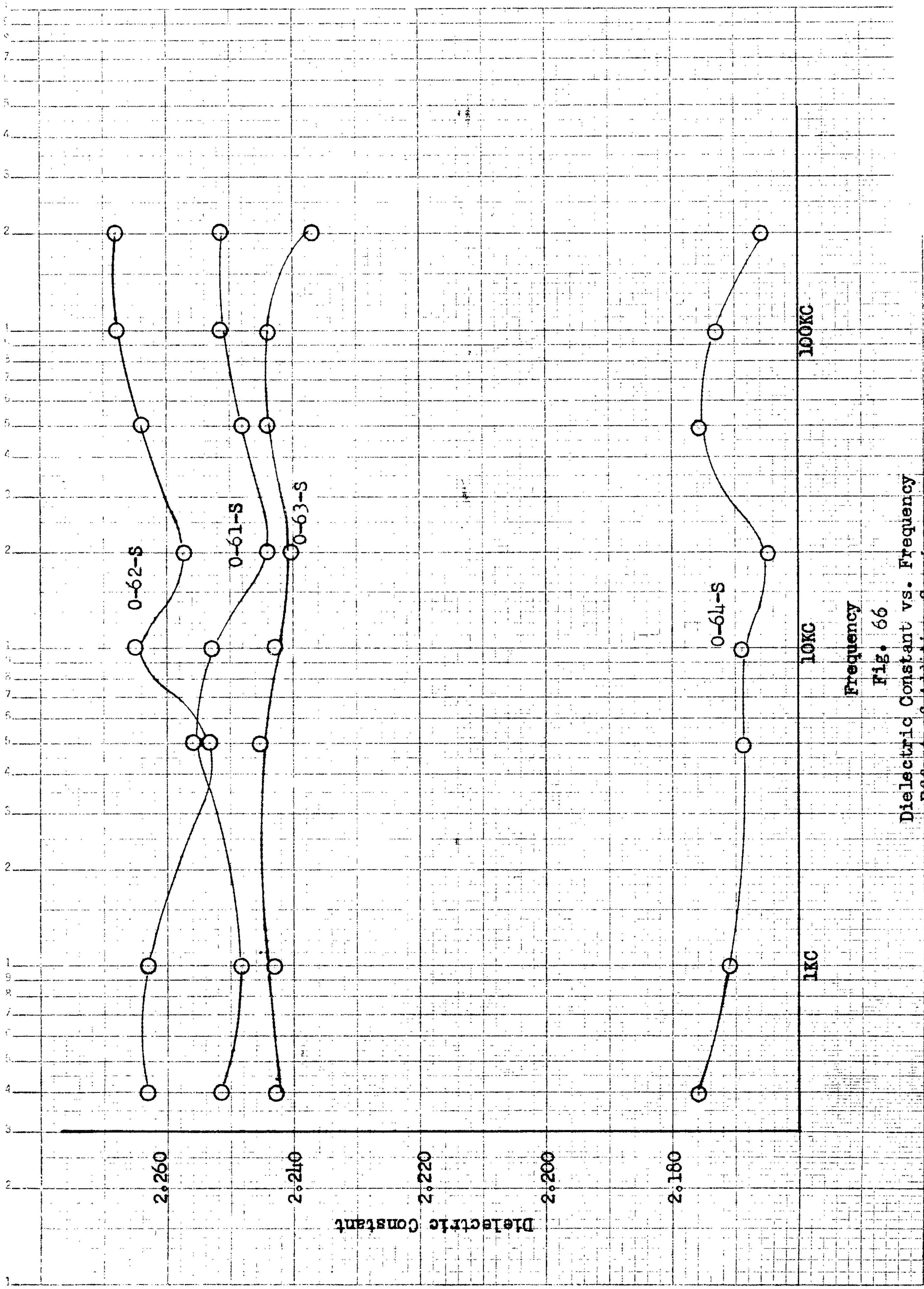
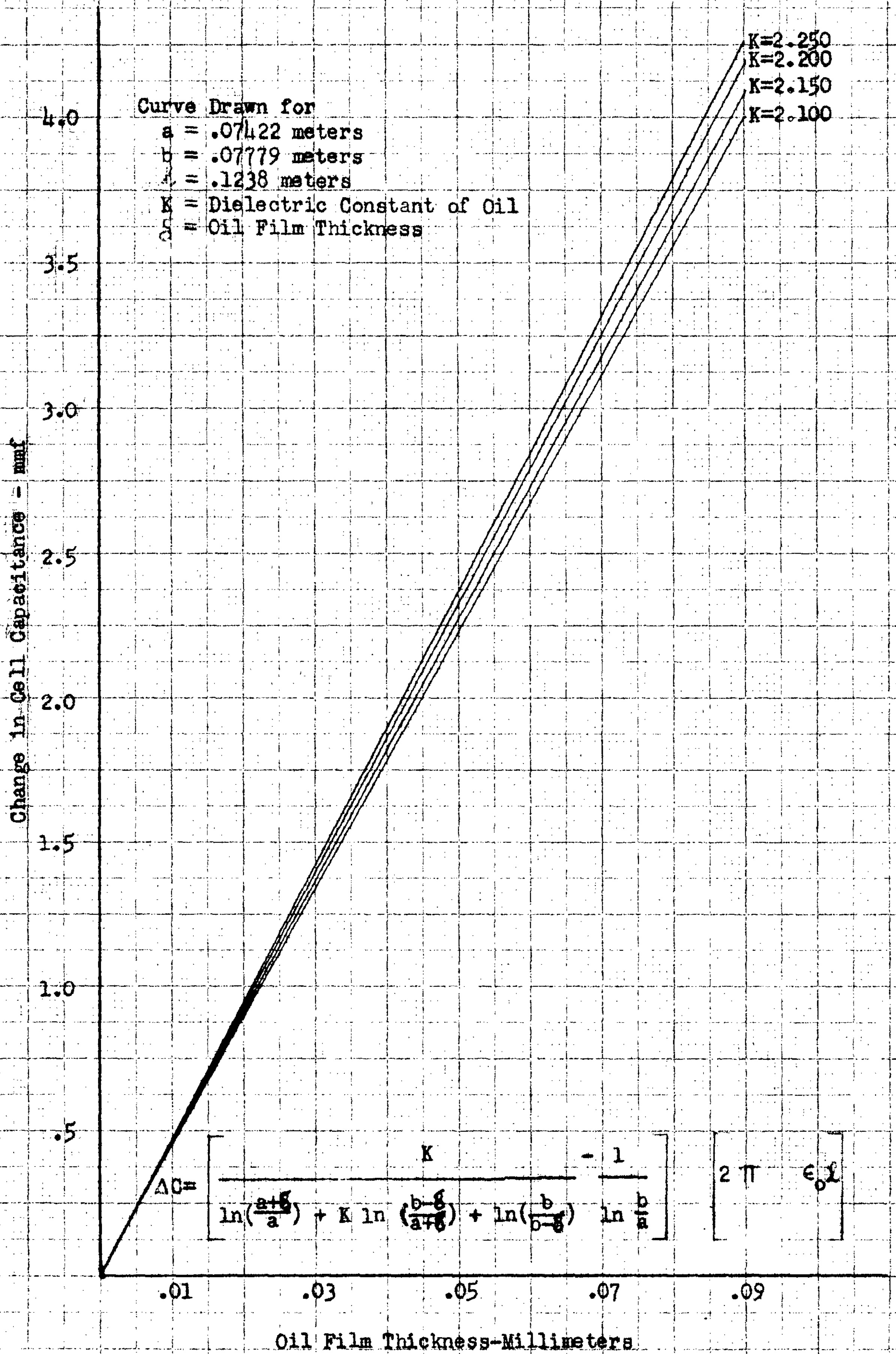


Fig. 66
Dielectric Constant vs. Frequency
Effect of Additive Specimens



$$\Delta C = \left[\frac{K}{\ln\left(\frac{a+\delta}{a}\right) + K \ln\left(\frac{b-\delta}{a+\delta}\right) + \ln\left(\frac{b}{b-\delta}\right)} - \frac{1}{\ln \frac{b}{a}} \right] \left[2\pi \quad \epsilon_0 \ell \right]$$

Fig. 67

Oil Film Characteristics

Table 1

DIELECTRIC CONSTANT AT 400 CYCLES PER SECOND
DENSITY IN AIR (LB/GALLON), AND CAPACITY INDEX
NEW OIL SPECIMENS

Specimen Number	Grade		Temperature, Degrees F					
			-41(-20°C)	32(0°C)	77(25°C)	130(54°C)	185(85°C)	200(93°C)
0-2-NR	1100	(DC)	2.281	2.261	2.234	2.196	2.162	2.154
		(D)	7.594	7.480	7.345	7.186	7.018	6.975
		(CI)	.1687	.1686	.1680	.1664	.1656	.1654
0-5-NR	1120	(DC)	2.306	2.285	2.256	2.219	2.190	2.182
		(D)	7.630	7.521	7.387	7.231	7.068	7.024
		(CI)	.1712	.1709	.1700	.1686	.1684	.1683
0-8-NR	1005	(DC)	2.176	2.162	2.139	2.108	2.072	2.064
		(D)	7.327	7.214	7.074	6.905	6.730	6.684
		(CI)	.1605	.1611	.1610	.1605	.1593	.1592
0-9-NR	1010	(DC)	2.234	2.218	2.186	2.151	2.136	2.133
		(D)	7.469	7.364	7.240	7.079	6.919	6.878
		(CI)	.1652	.1654	.1638	.1626	.1642	.1647
0-11-NR	1080	(DC)	2.296	2.275	2.246	2.215	2.180	2.171
		(D)	7.587	7.471	7.336	7.175	7.008	6.963
		(CI)	.1708	.1707	.1698	.1693	.1684	.1682

Table 2

DIELECTRIC CONSTANT AT 400 CYCLES PER SECOND
DENSITY IN AIR (LB/GALLON), AND CAPACITY INDEX
NEW OIL SPECIMENS

Specimen Number	Grade		Temperature, Degrees F -4(-20°C)	32(0°C)	77(25°C)	130(54°C)	185(85°C)	200(93°C)
0-12-NR	1065	(DC)	2.303	2.289	2.249	2.219	2.179	2.173
		(D)	7.550	7.445	7.313	7.161	7.002	6.960
		(CI)	.1726	.1731	.1708	.1702	.1684	.1685
0-13-NR	1080	(DC)	2.295	2.277	2.240	2.205	2.162	2.154
		(D)	7.538	7.432	7.298	7.141	6.977	6.935
		(CI)	.1718	.1718	.1699	.1687	.1665	.1664
0-17-NR	1005	(DC)	2.189	2.169	2.144	2.106	2.074	2.067
		(D)	7.263	7.162	7.027	6.888	6.700	6.657
		(CI)	.1637	.1632	.1628	.1606	.1603	.1603
0-18-NR	1100	(DC)	2.268	2.250	2.221	2.190	2.157	2.147
		(D)	7.553	7.448	7.316	7.164	7.005	6.963
		(CI)	.1679	.1678	.1669	.1661	.1652	.1647

Table 3

DIELECTRIC CONSTANT AT 400 CYCLES PER SECOND
DENSITY IN AIR (LB/GALLON), AND CAPACITY INDEX
NEW OIL SPECIMENS

Specimen Number	Grade		Temperature, Degrees F -40(-40°C)	-4(-20°C)	32(0°C)	77(25°C)	130(54°C)	185(85°C)	200(93°C)
0-33-NA	1065	(DC)	2.327	2.300	2.269	2.237	2.212	2.172	2.167
		(D)	7.670	7.558	7.447	7.311	7.152	6.984	6.942
		(CI)	.1730	.1720	.1704	.1692	.1695	.1678	.1681
0-34-NA	1010	(DC)	2.266	2.244	2.228	2.200	2.160	2.127	2.127
		(D)	7.566	7.454	7.341	7.205	7.046	6.884	6.836
		(CI)	.1673	.1669	.1673	.1666	.1646	.1637	.1649
0-36-NA	1080	(DC)	2.336	2.324	2.296	2.263	2.242	2.228	2.224
		(D)	7.725	7.614	7.502	7.365	7.206	7.053	6.996
		(CI)	.1729	.1739	.1728	.1715	.1734	.1741	.1750
0-38-NA	1100	(DC)	2.330	2.307	2.276	2.234	2.211	2.176	2.169
		(D)	7.716	7.606	7.494	7.356	7.192	7.035	6.975
		(CI)	.1724	.1718	.1703	.1678	.1684	.1672	.1676
0-41-NA	Hydraulic	(DC)	2.390	2.342	2.298	2.256	2.202	2.172	2.159
		(D)	7.489	7.375	7.260	7.118	6.948	6.776	6.724
		(CI)	.1856	.1820	.1788	.1764	.1730	.1730	.1724
0-44-NA	1010	(DC)	2.277	2.263	2.235	2.202	2.167	2.134	2.130
		(D)	7.586	7.474	7.362	7.222	7.058	6.901	6.841
		(CI)	.1683	.1690	.1678	.1664	.1654	.1643	.1652

Table 4

DIELECTRIC CONSTANT AT 400 CYCLES PER SECOND

DENSITY IN AIR (LB/GALLON), AND CAPACITY INDEX

USED OIL SPECIMENS

Specimen Number	Grade		Temperature, Degrees F						
			-40(-40°C)	-4(-20°C)	32(0°C)	77(25°C)	130(54°C)	185(85°C)	200(93°C)
0-35-UA	1010	(DC)	2.395	2.386	2.372	2.357	2.339	2.305	2.290
		(D)	7.819	7.706	7.593	7.452	7.286	7.115	7.067
		(CI)	.1784	.1799	.1807	.1821	.1838	.1834	.1825
0-37-UA	1080	(DC)	2.403	2.376	2.363	2.338	2.300	2.256	2.243
		(D)	7.675	7.571	7.467	7.330	7.184	7.001	6.982
		(CI)	.1828	.1817	.1825	.1825	.1810	.1794	.1780
0-40-UA	Hydraulic	(DC)	2.341	2.321	2.302	2.267	2.219	2.184	2.175
		(D)	7.468	7.353	7.238	7.094	6.924	6.752	6.700
		(CI)	.1796	.1796	.1799	.1786	.1760	.1753	.1754
0-49-UA	1100	(DC)	2.328	2.307	2.300	2.285	2.265	2.234	2.226
		(D)	7.735	7.628	7.513	7.374	7.210	7.036	6.994
		(CI)	.1717	.1713	.1730	.1743	.1754	.1754	.1753
0-50-UA	Hydraulic	(DC)	2.313	2.306	2.301	2.266	2.225	2.178	2.168
		(D)	7.503	7.390	7.276	7.134	6.967	6.795	6.746
		(CI)	.1750	.1767	.1788	.1775	.1758	.1734	.1731
0-51-UA	1065	(DC)	2.312	2.286	2.266	2.242	2.211	2.173	2.161
		(D)	7.651	7.543	7.435	7.300	7.141	6.970	6.931
		(CI)	.1715	.1705	.1703	.1701	.1696	.1683	.1675

Table 5

DIELECTRIC CONSTANT AT 400 CYCLES PER SECOND
DENSITY IN AIR (LB/GALLON), AND CAPACITY INDEX
USED OIL SPECIMENS DIRECT FROM AIRCRAFT

Specimen Number	MLO No.		Temperature, Degrees F -40(-40°C)	-4(-20°C)	32(0°C)	77(25°C)	130(54°C)	185(85°C)	200(93°C)
0-22-UB	MLO-5319	(DC)	2.243	2.224	2.197	2.184	2.143	2.103	2.095
		(D)	7.517	7.408	7.299	7.163	7.003	6.822	6.791
		(CI)	.1654	.1652	.1640	.1653	.1632	.1617	.1612
0-23-UB	MLO-5320	(DC)	2.248	2.237	2.215	2.180	2.141	2.112	2.102
		(D)	7.532	7.421	7.311	7.173	7.011	6.831	6.796
		(CI)	.1657	.1667	.1662	.1645	.1628	.1628	.1622
0-24-UB	MLO-5321	(DC)	2.385	2.340	2.320	2.284	2.243	2.209	2.197
		(D)	7.731	7.624	7.518	7.385	7.228	7.064	7.021
		(CI)	.1792	.1758	.1756	.1739	.1720	.1711	.1705
0-25-UB	MLO-5322	(DC)	2.410	2.386	2.356	2.314	2.265	2.199	2.185
		(D)	7.738	7.629	7.520	7.384	7.224	7.054	7.012
		(CI)	.1822	.1817	.1803	.1780	.1751	.1700	.1690
0-26-UB	MLO-5323	(DC)	2.423	2.405	2.377	2.348	2.307	2.269	2.255
		(D)	7.785	7.676	7.567	7.431	7.271	7.112	7.059
		(cI)	.1828	.1830	.1820	.1814	.1798	.1784	.1778
0-27-UB	MLO-5324	(DC)	2.388	2.368	2.344	2.320	2.282	2.250	2.239
		(D)	7.768	7.661	7.555	7.422	7.265	7.114	7.058
		(CI)	.1787	.1786	.1779	.1779	.1764	.1757	.1754

Table 6

DIELECTRIC CONSTANT AT 400 CYCLES PER SECOND
DENSITY IN AIR (LB/GALLON), AND CAPACITY INDEX
10% DILUTED SPECIMENS

Specimen Number	Grade		Temperature, Degrees F -40(-40°C)	-4(-20°C)	32(0°C)	77(25°C)	130(54°C)	185(85°C)
0-2-10D	1100	(DC)	2.307	2.278	2.255	2.233	2.192	2.175
		(D)	7.563	7.448	7.333	7.197	7.042	6.863
		(CI)	.1728	.1716	.1711	.1713	.1693	.1712
0-5-10D	1120	(DC)	---	2.278	2.255	2.224	2.181	2.155
		(D)	---	7.528	7.413	7.276	7.110	6.933
		(CI)	---	.1698	.1693	.1682	.1661	.1666
0-7-10D	1010	(DC)	2.233	2.211	2.191	2.169	2.133	2.121
		(D)	7.448	7.336	7.220	7.082	6.917	6.745
		(CI)	.1655	.1651	.1650	.1650	.1638	.1662
0-8-10D	1005	(DC)	2.209	2.182	2.159	2.130	2.097	2.072
		(D)	7.336	7.219	7.101	6.960	6.802	6.620
		(CI)	.1648	.1637	.1632	.1624	.1613	.1619
0-11-10D	1080	(DC)	2.301	2.272	2.247	2.223	2.177	---
		(D)	7.561	7.445	7.330	7.193	7.034	---
		(CI)	.1721	.1709	.1701	.1700	.1673	---
0-13-10D	1080	(DC)	---	2.252	2.231	2.201	2.159	2.127
		(D)	---	7.406	7.291	7.149	6.980	6.800
		(CI)	---	.1691	.1688	.1680	.1660	.1657

Table 7

DIELECTRIC CONSTANT AT 400 CYCLES PER SECOND
DENSITY IN AIR (LB/GALLON), AND CAPACITY INDEX
10% DILUTED SPECIMENS

Specimen Number	Grade		Temperature, Degrees F					
			-40(-40°C)	-4(-20°C)	32(0°C)	77(25°C)	130(54°C)	185(85°C)
0-15-10D	1065	(DC)	2.283	2.245	2.222	2.201	2.160	---
		(D)	7.494	7.381	7.261	7.127	6.975	---
		(CI)	.1712	.1687	.1683	.1685	.1663	---
0-16-10D	1100	(DC)	2.284	2.254	2.233	2.208	2.173	---
		(D)	7.554	7.442	7.330	7.186	7.034	---
		(CI)	.1700	.1685	.1682	.1681	.1668	---
0-18-10D	1100	(DC)	---	2.253	2.230	2.201	2.168	2.142
		(D)	---	7.436	7.322	7.180	7.012	6.831
		(CI)	---	.1685	.1680	.1673	.1666	.1677
0-19-10D	1010	(DC)	---	2.217	2.195	2.163	2.128	2.091
		(D)	---	7.287	7.174	7.032	6.875	6.704
		(CI)	---	.1670	.1666	.1654	.1641	.1627
0-20-10D	1100	(DC)	---	2.284	2.257	2.224	2.182	2.141
		(D)	---	7.487	7.371	7.229	7.063	6.890
		(CI)	---	.1715	.1705	.1693	.1674	.1656
0-21-10D	1100	(DC)	---	2.246	2.225	2.194	2.160	2.137
		(D)	---	7.447	7.333	7.192	7.023	6.850
		(CI)	---	.1673	.1671	.1660	.1652	.1660

Table 8

DIELECTRIC CONSTANT AT 400 CYCLES PER SECOND
DENSITY IN AIR (LB/GALLON), AND CAPACITY INDEX
20% DILUTED SPECIMENS

Specimen Number	Grade		Temperature, Degrees F						
			-65(-54°C)	-40(-40°C)	-4(-20°C)	32(0°C)	77(25°C)	130(54°C)	185(85°C)
0-2-20D	1100	(DC)	2.302	2.291	2.265	2.228	2.193	2.171	2.162
		(D)	7.484	7.405	7.293	7.180	7.041	6.879	6.703
		(CI)	.1743	.1743	.1735	.1710	.1694	.1702	.1734
0-5-20D	1120	(DC)	—	2.255	2.233	2.205	2.178	—	2.148
		(D)	—	7.447	7.336	7.225	7.084	—	6.747
		(CI)	—	.1685	.1681	.1668	.1663	—	.1701
0-8-20D	1005	(DC)	2.196	2.185	2.158	2.125	2.100	2.070	2.059
		(D)	7.257	7.176	7.061	6.949	6.802	6.643	6.458
		(CI)	.1648	.1651	.1640	.1619	.1617	.1611	.1640
0-11-20D	1080	(DC)	2.291	2.271	2.244	2.209	2.176	2.155	2.151
		(D)	7.480	7.400	7.289	7.177	7.037	6.869	6.699
		(CI)	.1726	.1718	.1707	.1685	.1671	.1681	.1718

Table 9

DIELECTRIC CONSTANT AT 400 CYCLES PER SECOND
DENSITY IN AIR (LB/GALLON), AND CAPACITY INDEX
20% DILUTED SPECIMENS

Specimen Number	Grade		Temperature, Degrees F -40(-40°C)	-4(-20°C)	32(0°C)	77(25°C)	185(85°C)
0-12-20D	1065	(DC)	2.249	2.229	2.203	2.176	2.150
		(D)	7.368	7.255	7.142	7.000	6.661
		(CI)	.1695	.1694	.1684	.1680	.1726
0-13-20D	1080	(DC)	2.258	2.233	2.203	2.179	2.144
		(D)	7.379	7.269	7.154	7.013	6.675
		(CI)	.1705	.1696	.1682	.1681	.1714
0-17-20D	1005	(DC)	2.188	2.171	2.141	2.107	2.081
		(D)	7.163	7.052	6.942	6.800	6.456
		(CI)	.1659	.1661	.1644	.1628	.1674
0-18-20D	1100	(DC)	2.237	2.217	2.192	2.163	2.148
		(D)	7.408	7.286	7.175	7.033	6.695
		(CI)	.1670	.1670	.1661	.1654	.1715

Table 10

DIELECTRIC CONSTANT AT 400 CYCLES PER SECOND
DENSITY IN AIR (LB/GALLON), AND CAPACITY INDEX
30% DILUTED SPECIMENS

Specimen Number	Grade		Temperature, Degrees F -65(-54°C)	-40(-40°C)	-4(-20°C)	32(0°C)	77(25°C)	130(54°C)	185(85°C)
0-2-30D	1100	(DC)	2.261	2.241	2.219	2.190	2.164	2.139	2.136
		(D)	7.363	7.285	7.170	7.058	6.919	6.755	6.578
		(CI)	.1713	.1704	.1700	.1686	.1682	.1686	.1727
0-5-30D	1120	(DC)	——	2.251	2.223	2.200	2.178	——	2.148
		(D)	——	7.297	7.186	7.074	6.933	——	6.593
		(CI)	——	.1714	.1702	.1696	.1699	——	.1741
0-7-30D	1010	(DC)	2.215	2.193	2.167	2.141	2.109	2.090	2.088
		(D)	7.273	7.191	7.073	6.956	6.812	6.652	6.469
		(CI)	.1671	.1659	.1650	.1640	.1628	.1639	.1682
0-8-30D	1005	(DC)	2.201	2.181	2.149	2.126	2.097	2.075	2.059
		(D)	7.168	7.085	6.968	6.846	6.698	6.526	6.352
		(CI)	.1676	.1667	.1649	.1645	.1638	.1647	.1667
0-9-30D	1010	(DC)	2.240	2.205	2.179	2.157	2.132	——	2.103
		(D)	7.279	7.200	7.091	6.975	6.829	——	6.486
		(CI)	.1704	.1674	.1663	.1659	.1658	——	.1701

Table 11

DIELECTRIC CONSTANT AT 400 CYCLES PER SECOND
DENSITY IN AIR (LB/GALLON), AND CAPACITY INDEX
30% DILUTED SPECIMENS

Specimen Number	Grade		Temperature, Degrees F						
			-65(-54°C)	-40(-40°C)	-4(-20°C)	32(0°C)	77(25°C)	130(54°C)	185(85°C)
0-11-30D	1080	(DC)	2.290	2.264	2.240	2.215	2.175	2.152	2.150
		(D)	7.358	7.280	7.165	7.051	6.910	6.744	6.569
		(CI)	.1747	.1736	.1731	.1723	.1715	.1708	.1751
0-12-30D	1065	(DC)	2.295	2.244	2.209	2.187	2.168	———	2.150
		(D)	7.268	7.230	7.118	7.005	6.864	———	6.522
		(CI)	.1782	.1721	.1699	.1695	.1702	———	.1763
0-13-30D	1080	(DC)	———	2.223	2.197	2.168	2.145	———	2.121
		(D)	———	7.269	7.160	7.050	6.907	———	6.566
		(CI)	———	.1682	.1672	.1657	.1658	———	.1707
0-17-30D	1005	(DC)	2.205	2.164	2.137	2.117	2.087	———	2.059
		(D)	7.119	7.041	6.931	6.812	6.671	———	6.324
		(CI)	.1693	.1653	.1640	.1640	.1629	———	.1675
0-18-30D	1100	(DC)	———	2.227	2.199	2.179	2.159	———	2.142
		(D)	———	7.277	7.167	7.056	6.916	———	6.575
		(CI)	———	.1686	.1673	.1671	.1676	———	.1737

Table 12

DISSIPATION FACTOR AT 400 CPS
(Only Values greater than 0.0007)

Specimen Number	Grade	Temperature, Degrees F -4(-20°C)	32(0°C)	77(25°C)	130(54°C)	185(85°C)	200(93°C)
0-2-NR	1100	---	---	---	---	.0037	.0047
0-5-NR	1120	---	---	---	---	---	.0017
0-8-NR	1005	---	---	---	.0023	.0056	.0060
0-9-NR	1010	.0012	.0033	.0142	.0685	.1760	.1910
0-11-NR	1080	---	---	---	---	.0011	.0013
0-12-NR	1065	---	---	---	---	.0010	.0019
0-13-NR	1080	---	---	---	.0032	.0125	.0153
0-17-NR	1005	---	---	---	.0017	.0047	.0051
0-18-NR	1100	---	---	---	---	---	.0034
0-7-10D	1010	---	.0008	.0034	.0061	---	---
0-8-10D	1005	---	---	.0008	.0024	---	---
0-2-20D	1100	---	---	---	.0019	---	---
0-8-20D	1005	---	---	---	.0081	---	---
0-2-30D	1100	---	---	.0008	.0028	---	---
0-7-30D	1010	---	---	.0027	.0073	---	---
0-8-30D	1005	---	---	.0011	.0040	---	---

Table 13

DISSIPATION FACTORS AT 400 CPS
(Only Values Exceeding 0.0007)

Specimen Number	Grade or MLO No.	Temperature, Degrees F						
		-40(-40°C)	-4(-20°C)	32(0°C)	77(25°C)	130(54°C)	185(85°C)	200(93°C)
0-33-NA	1065	---	---	---	---	0.0007	0.0021	0.0028
0-34-NA	1010	---	---	---	---	0.0021	0.0045	0.0051
0-36-NA	1080	---	---	---	---	0.0007	.0023	0.0028
0-38-NA	1100	---	---	---	---	---	.0022	0.0026
0-41-NA	Hydraulic	---	---	---	---	0.008	.0039	0.0041
0-44-NA	1010	---	---	---	0.0069	0.0102	.0475	0.0665
0-35-UA	1010	---	.0008	.0090	.0275	.1777	.7690	1.0700
0-37-UA	1080	---	.0180	.0835	.40321	1.5557	3.5300	5.0200
0-40-UA	Hydraulic	---	---	.0020	.0087	.0107	.0238	.0251
0-49-UA	1100	---	---	.0031	.0098	.0629	.1345	.3980
0-50-UA	Hydraulic	---	.0042	.0077	.0262	.0633	.1340	.1620
0-51-UA	1065	---	---	.0011	.0073	.0300	.3420	.4130
0-22-UB	MLO-5319	.0011	.0064	.0124	.0485	.0806	.2050	.5320
0-23-UB	MLO-5320	.0008	.0068	.0114	.0463	.0791	.2480	.5790
0-24-UB	MLO-5321	---	---	.0007	.0010	.0024	.0084	.0090
0-25-UB	MLO-5322	---	---	---	.0008	.0027	.0107	.0123
0-26-UB	MLO-5323	---	---	.0007	.0013	.0097	.0591	.0800
0-27-UB	MLO-5324	---	---	.0008	.0014	.0107	.0623	.0684

Table 14

DIELECTRIC CONSTANT, DENSITY, CAPACITY INDEX, AND
DISSIPATION FACTOR AT 185°F(85°C) AND 400 CPS
NEW OILS FROM REFINERIES

Specimen Number	Grade	Dielectric Constant	Density Lb/Gallon	Capacity Index (K-1)/D	Dissipation Factor
0-1-NR	1100	2.194	7.053	.1693	---
0-2-NR	1100	2.162	7.018	.1656	.0037
0-3-NR	1100	2.195	7.076	.1689	.0008
0-4-NR	1100	2.192	7.067	.1687	.0013
0-5-NR	1120	2.190	7.068	.1684	---
0-6-NR	1100	2.190	7.048	.1688	.0007
0-7-NR	1010	2.111	6.889	.1613	.0154
0-8-NR	1005	2.072	6.730	.1593	.0056
0-9-NR	1010	2.136	6.919	.1642	.1760
0-10-NR	1100	2.177	7.017	.1677	---
0-11-NR	1080	2.180	7.008	.1684	.0011
0-12-NR	1065	2.179	7.002	.1684	.0010
0-13-NR	1080	2.162	6.977	.1665	.0125
0-14-NR	1100	2.179	7.059	.1670	.0007
0-15-NR	1065	2.150	6.932	.1659	---
0-16-NR	1100	2.171	7.002	.1672	.0008
0-17-NR	1005	2.074	6.700	.1603	.0047
0-18-NR	1100	2.157	7.005	.1652	---
0-19-NR	1010	2.147	6.834	.1678	.0044
0-20-NR	1100	2.178	7.050	.1671	.0020
0-21-NR	1100	2.150	7.007	.1641	---
0-55-NR	1010	2.137	6.864	.1656	.0028

Table 15

DIELECTRIC CONSTANT, DENSITY, CAPACITY INDEX AND DISSIPATION FACTOR AT 185°F (85°C) AND 400 CPS

NEW OILS FROM AIR FORCE BASES

Specimen Number	Grade	Dielectric Constant	Density Lb/Gallon	Capacity Index (K-1)/D	Dissipation Factor
0-32-NA	1010	2.124	6.885	.1633	.0225
0-33-NA	1065	2.172	6.984	.1678	.0021
0-34-NA	1010	2.127	6.884	.1637	.0045
0-36-NA	1080	2.228	7.053	.1741	.0023
0-38-NA	1100	2.176	7.035	.1672	.0022
0-41-NA	Hydraulic	2.172	6.776	.1730	.0039
0-44-NA	1010	2.134	6.901	.1643	.0475
0-45-NA	1100	2.167	7.064	.1652	.0016
0-46-NA	Hydraulic	2.162	6.794	.1710	.0022
0-47-NA	1100	2.184	7.042	.1681	.0015
0-48-NA	1065	2.163	6.968	.1669	.0096
0-52-NA	1080	2.187	7.034	.1688	.0012
0-53-NA	Hydraulic	2.093	6.850	.1596	.0074
0-66-NA	1010	2.106	6.892	.1605	.0083
0-67-NA	1080	2.268	6.968	.1820	.0050
0-68-NA	1100	2.189	7.053	.1686	.0014
0-69-NA	1065	2.171	6.978	.1678	.0018

Table 16

DIELECTRIC CONSTANT, DENSITY, CAPACITY INDEX, AND DISSIPATION FACTOR AT 185°F (85°C) AND 400 CPS USED OILS FROM AIR FORCE BASES

Specimen Number	Grade	Engine Time (hrs)	Dielectric Constant	Density Lb/Gallon	Capacity Index (K-1)/D	Dissipation Factor
0-35-UA	1010	10:00	2.305	7.115	.1834	.7690
0-37-UA	1080	220:00	2.256	7.001	.1794	3.5300
0-39-UA	1100	1140:00	2.266	7.123	.1777	.0446
0-40-UA	Hydraulic Oil	1200:00	2.184	6.752	.1754	.0238
0-49-UA	1100	235:00	2.234	7.087	.1741	.1345
0-50-UA	Hydraulic Oil	235:00	2.178	6.795	.1734	.1340
0-51-UA	1065	235:00	2.173	6.970	.1683	.3420
0-54-UA	1065	78:00	2.166	6.942	.1680	.0212
0-70-UA	1010	95:55	2.053	6.910	.1524	.1195
0-71-UA	1080	29:00	2.202	6.984	.1721	.0018
0-72-UA	1100	90:50	2.259	7.104	.1772	.0276
0-73-UA	Hydraulic	78:00	2.006	6.883	.1462	.6253

Table 17

DIELECTRIC CONSTANT, DENSITY, CAPACITY INDEX, AND DISSIPATION FACTOR AT 185°F (85°C) AND 400 CPS

USED OIL DIRECT FROM AIRCRAFT

Specimen Number	MLO No.	Type of Aircraft	Engine Number	Engine Time (hrs)	Oil Time (hrs)	Dielectric Constant	Density Lb/Gallon	Capacity Index	Dissipation Factor
0-22-UB	5319	B-45	1	50:10	2:05	2.103	6.822	.1617	.2050
0-23-UB	5320	B-45	2	50:10	2:05	2.112	6.831	.1628	.2480
0-24-UB	5321	B-29	2	357:50	4:20	2.209	7.064	.1711	.0084
0-25-UB	5322	B-29	3	139:05	4:20	2.199	7.054	.1700	.0107
0-26-UB	5323	B-50	1	281:10	281:10	2.269	7.112	.1784	.0591
0-27-UB	5324	B-50	2	281:10	281:10	2.250	7.114	.1757	.0623
0-28-UB	5325	C-97A	2	503:00	—	2.252	7.067	.1772	.0060
0-29-UB	5326	C-97A	3	503:00	—	2.242	7.079	.1754	.0080
0-30-UB	5327	C-124	2	—	18:40	2.218	7.026	.1734	.0292
0-31-UB	5328	C-124	3	—	18:40	2.221	7.023	.1739	.0296
0-42-UB	5581		2	16:35	—	2.183	7.039	.1681	.0009
0-43-UB	5582		3	86:35	—	2.218	7.052	.1727	.0039
0-77-UB	6018	B-45	1	229:15	—	2.141	6.884	.1657	.1658
0-78-UB	6019	B-45	2	147:45	—	2.142	6.868	.1663	.0892
0-79-UB	6020	B-29	1	171:40	—	2.262	7.074	.1784	.0200
0-80-UB	6021	B-29	4	54:15	—	2.220	7.044	.1732	.0038
0-81-UB	6022	B-17	3	1125:25	—	2.255	7.043	.1782	.1512
0-82-UB	6023	B-17	2	331:25	—	2.261	7.084	.1780	.1155
0-83-UB	6024	B-50	3	108:10	—	2.247	7.023	.1776	.0986
0-84-UB	6025	B-50	4	104:50	—	2.253	7.060	.1775	.1148

Table 18

DIELECTRIC CONSTANT, DENSITY, CAPACITY INDEX, AND DISSIPATION FACTOR AT 185°F (85°C) AND 400 CPS PAIR SAMPLES

Specimen Number	Grade	Dielectric Constant	Density Lb/Gallon	Capacity Index (K-1)/D	Dissipation Factor
0-47-NA (New)	1100	2.184	7.042	.1681	.0015
0-39-UA (Used)		2.266	7.123	.1777	.0446
0-38-NA (New	1100	2.176	7.035	.1672	.0022
0-49-UA (Used)		2.234	7.087	.1741	.1345
0-68-NA (New)	1100	2.189	7.053	.1686	.0014
0-72-UA (Used)		2.259	7.104	.1772	.0276
0-33-NA (New)	1065	2.172	6.984	.1678	.0021
0-51-UA (Used)		2.173	6.970	.1683	.3420
0-69-NA (New)	1065	2.171	6.978	.1678	.0018
0-54-UA (Used)		2.166	6.942	.1680	.0212
0-36-NA (New)	1080	2.228	7.053	.1741	.0023
0-37-UA (Used)		2.256	7.001	.1794	3.5300
0-67-NA (New)	1080	2.268	6.968	.1820	.0050
0-71-UA (Used)		2.202	6.984	.1721	.0018
0-34-NA (New)	1010	2.127	6.884	.1637	.0045
0-35-UA (Used)		2.305	7.115	.1834	.7690
0-66-NA (New)	1010	2.106	6.892	.1605	.0083
0-70-UA (Used)		2.053	6.910	.1524	.1195
0-41-NA (New)	Hydraulic	2.172	6.776	.1730	.0039
0-40-UA (Used)		2.184	6.752	.1754	.0238
0-46-NA (New)	Hydraulic	2.162	6.794	.1710	.0022
0-50-UA (Used)		2.178	6.795	.1734	.1340
0-53-NA (New)	Hydraulic	2.093	6.850	.1596	.0074
0-73-UA (Used)		2.006	6.883	.1462	.6253

Table 19

MEAN VALUES AT 400 CPS AND 185°F (85°C)
(NEW OILS)

Grade	Number of Specimens	Mean Dielectric Constant	Mean Density	Mean Capacity Index
1100	15	2.177	7.040	.1672
1080	5	2.205	7.008	.1720
1065	5	2.167	6.973	.1674
1010	8	2.128	6.884	.1638
1005	2	2.073	6.715	.1598
Hydraulic	3	2.142	6.807	.1679
1120	1	2.190	7.068	.1684

Table 20

MEAN VALUES AT 400 CPS AND 185°F (85°C)
(USED OILS FROM AIR FORCE BASES)

Grade	Number of Specimens	Mean Dielectric Constant	Mean Density	Mean Capacity Index
1100	3	2.253	7.105	.1763
1080	2	2.229	6.993	.1758
1065	2	2.170	6.956	.1682
1010	2	2.179	7.013	.1679
Hydraulic	3	2.123	6.810	.1650
USED OILS DIRECT FROM AIRCRAFT				
UB Specimens	20	2.213	7.018	.1728

Table 21

SLOPE OF DENSITY VS. TEMPERATURE CURVES
AS A FUNCTION OF DENSITY
NEW OILS

Specimen Number	Grade	Density at 185°F (85°C) Pounds per Gallon	Change in Density per Deg. F Pounds per Gallon $x10^{-4}$
0-1-NR	1100	7.053	30.4
0-2-NR	1100	7.018	30.2
0-3-NR	1100	7.076	29.5
0-4-NR	1100	7.067	29.9
0-5-NR	1120	7.068	29.6
0-6-NR	1100	7.048	29.9
0-7-NR	1010	6.889	30.3
0-8-NR	1005	6.730	31.6
0-9-NR	1010	6.919	30.7
0-10-NR	1100	7.017	29.1
0-11-NR	1080	7.008	30.3
0-12-NR	1065	7.002	29.0
0-13-NR	1080	6.977	29.7
0-14-NR	1100	7.059	29.3
0-15-NR	1065	6.932	29.7
0-16-NR	1100	7.002	30.0
0-17-NR	1005	6.700	30.2
0-18-NR	1100	7.005	29.7
0-19-NR	1010	6.834	31.5
0-20-NR	1100	7.050	30.6
0-21-NR	1100	7.007	30.3
0-32-NA	1010	6.885	30.1
0-33-NA	1065	6.984	30.3
0-34-NA	1010	6.884	29.9
0-36-NA	1080	7.053	29.3
0-38-NA	1100	7.035	30.0
0-41-NA	Hydraulic	6.776	31.6
0-44-NA	1010	6.901	30.1
0-45-NA	1100	7.064	29.7
0-46-NA	Hydraulic	6.794	31.2
0-47-NA	1100	7.042	29.7
0-48-NA	1065	6.968	30.3
0-52-NA	1080	7.034	29.9
0-53-NA	Hydraulic	6.850	31.4
0-55-NR	1010	6.864	31.0
0-66-NA	1010	6.892	30.3
0-67-NA	1080	6.968	30.0
0-68-NA	1100	7.053	29.5
0-69-NA	1065	6.978	30.3

Table 22

SLOPE OF DENSITY VS. TEMPERATURE CURVES
AS A FUNCTION OF DENSITY
USED OILS

Specimen Number	Grade or MLO No.	Density at 185°F (85°C) Pounds per Gallon	Change in Density per Deg. F Pounds per Gallon x10^{-4}
0-35-UA	1010	7.115	31.2
0-37-UA	1080	7.001	30.5
0-39-UA	1100	7.123	30.4
0-40-UA	Hydraulic	6.752	31.8
0-49-UA	1100	7.087	27.8
0-50-UA	Hydraulic	6.795	31.4
0-51-UA	1065	6.970	30.4
0-54-UA	1065	6.942	29.9
0-70-UA	1010	6.910	31.3
0-71-UA	1080	6.984	30.3
0-72-UA	1100	7.104	30.3
0-73-UA	Hydraulic	6.883	30.1
0-22-UB	MLO-5319	6.822	31.2
0-23-UB	MLO-5320	6.831	31.4
0-24-UB	MLO-5321	7.064	29.7
0.25-UB	MLO-5322	7.054	30.5
0-26-UB	MLO-5323	7.112	29.7
0-27-UB	MLO-5324	7.114	28.8
0-28-UB	MLO-5325	7.067	30.6
0-29-UB	MLO-5326	7.079	30.1
0-30-UB	MLO-5327	7.026	29.9
0-31-UB	MLO-5328	7.023	30.2
0-42-UB	MLO-5581	7.039	30.7
0-43-UB	MLO-5582	7.052	30.5
0-77-UB	MLO-6018	6.884	30.0
0-78-UB	MLO-6019	6.868	30.6
0-79-UB	MLO-6020	7.074	31.0
0-80-UB	MLO-6021	7.044	30.7
0-81-UB	MLO-6022	7.043	31.0
0-82-UB	MLO-6023	7.084	30.2
0-83-UB	MLO-6024	7.023	31.0
0-84-UB	MLO-6025	7.060	30.0

Table 23

SLOPE OF DENSITY VS. TEMPERATURE CURVES
AS A FUNCTION OF DENSITY
DILUTED OILS

Specimen Number	Grade	Density at 77°F (25°C) Pounds per Gallon	Change in Density per Deg. F Pounds per Gallon x10^{-4}
0-2-10D	1100	7.197	30.2
0-5-10D	1120	7.276	30.4
0-7-10D	1010	7.082	30.7
0-8-10D	1005	6.960	31.3
0-11-10D	1080	7.193	30.4
0-13-10D	1080	7.149	31.6
0-15-10D	1065	7.127	29.8
0-16-10D	1100	7.186	32.0
0-18-10D	1100	7.180	31.6
0-19-10D	1010	7.032	31.6
0-20-10D	1100	7.229	31.6
0-21-10D	1100	7.192	31.3
0-2-20D	1100	7.041	30.9
0-5-20D	1120	7.084	31.3
0-8-20D	1005	6.802	32.7
0-11-20D	1080	7.037	31.1
0-12-20D	1065	7.000	31.6
0-13-20D	1080	7.013	31.3
0-17-20D	1005	6.800	31.6
0-18-20D	1100	7.033	31.6
0-2-30D	1100	6.919	30.9
0-5-30D	1120	6.933	31.3
0-7-30D	1010	6.812	32.0
0-8-30D	1005	6.698	32.9
0-9-30D	1010	6.829	32.4
0-11-30D	1080	6.910	31.3
0-12-30D	1065	6.864	31.3
0-13-30D	1080	6.907	31.8
0-17-30D	1005	6.671	31.3
0-18-30D	1100	6.916	31.1

Table 24

MEAN TEMPERATURE COEFFICIENTS OF DIELECTRIC CONSTANT AT 185°F (85°C)
NEW OIL

Grade	Mean Slope of Dielectric Constant vs. Temperature Curves Per Degree F	Mean Dielectric Constant at 185°F (85°C), 400 cps	Mean Temperature Coefficient of Dielectric Constant at 185°F (85°C) Per Degree F	Per Degree C
1100	0.000627	2.177	0.000288	0.000518
1080	0.000609	2.205	0.000276	0.000497
1065	0.000667	2.167	0.000308	0.000554
1010	0.000607	2.128	0.000285	0.000513
1005	0.000601	2.073	0.000290	0.000522
Hydraulic	0.000899	2.142	0.000420	0.000756
1120	0.000614	2.190	0.000280	0.000504

$$K_{t(°F)} = K_{185}\left[1 - \alpha_F(t-185)\right] \quad \text{or} \quad K_{t(°C)} = K_{85}\left[1 - \alpha_C(t-85)\right]$$

Table 25

MEAN TEMPERATURE COEFFICIENTS OF DIELECTRIC CONSTANT AT 185°F (85°C)
USED OILS

Grade	Mean Slope of Dielectric Constant vs. Temperature Curves Per Degree F	Mean Dielectric Constant at 185°F (85°C), 400 cps	Mean Temperature Coefficient of Dielectric Constant at 185°F (85°C) Per Degree F	Per Degree C
1100	0.000418	2.253	0.000186	0.000335
1080	0.000637	2.229	0.000286	0.000515
1065	0.000617	2.170	0.000284	0.000511
1010	0.000400	2.179	0.000184	0.000331
Hydraulic	0.000615	2.123	0.000290	0.000522
UB Specimens	0.000701	2.213	0.000317	0.000571

$$K_{t(°F)} = K_{185} \left[1 - \alpha_F (t-185) \right] \quad \text{or} \quad K_{t(°C)} = K_{85} \left[1 - \alpha_C (t-85) \right]$$

Table 26

MEAN TEMPERATURE COEFFICIENTS OF DIELECTRIC CONSTANT AT 77°F (25°C)

10% DILUTED OILS

Grade	Mean Slope of Dielectric Constant vs. Temperature Curves Per Degree F	Mean Dielectric Constant at 77°F (25°C), 400 cps	Mean Temperature Coefficient of Dielectric Constant at 77°F (25°C) Per Degree F	Per Degree C
1100	0.000652	2.221	0.000294	0.000529
1080	0.000691	2.212	0.000312	0.000562
1065	0.000724	2.198	0.000329	0.000592
1010	0.000624	2.168	0.000288	0.000518
1005	0.000664	2.125	0.000312	0.000562
1120	0.000653	2.224	0.000294	0.000529

$$K_{t(°F)} = K_{77}\left[1 - \alpha_F(t-77)\right] \quad \text{or} \quad K_{t(°C)} = K_{25}\left[1 - \alpha_C(t-25)\right]$$

Table 27

MEAN TEMPERATURE COEFFICIENTS OF DIELECTRIC CONSTANT AT 77°F (25°C)
20% DILUTED OILS

Grade	Mean Slope of Dielectric Constant vs. Temperature Curves Per Degree F	Mean Dielectric Constant at 77°F (25°C), 400 cps	Mean Temperature Coefficient of Dielectric Constant at 77°F (25°C) Per Degree F	Per Degree C
1100	0.000654	2.186	0.000299	0.000538
1080	0.000692	2.178	0.000318	0.000572
1065	0.000626	2.162	0.000290	0.000522
1005	0.000667	2.104	0.000317	0.000571
1120	0.000663	2.178	0.000304	0.000547

$$K_{t(°F)} = K_{77}\left[1 - \alpha_F(t-77)\right] \quad \text{or} \quad K_{t(°C)} = K_{25}\left[1 - \alpha_C(t-25)\right]$$

Table 28

MEAN TEMPERATURE COEFFICIENTS OF DIELECTRIC CONSTANT AT 77°F (25°C)

30% DILUTED OILS

Grade	Mean Slope of Dielectric Constant vs. Temperature Curves Per Degree F	Mean Dielectric Constant at 77°F (25°C), 400 cps	Mean Temperature Coefficient of Dielectric Constant at 77°F (25°C) Per Degree F	Per Degree C
1100	0.000605	2.161	0.000280	0.000504
1080	0.000676	2.160	0.000313	0.000563
1065	0.000650	2.157	0.000301	0.000542
1010	0.000629	2.123	0.000296	0.000533
1005	0.000653	2.092	0.000312	0.000562
1120	0.000635	2.178	0.000292	0.000526

$$K_{t(°F)} = K_{77}\left[1 - \alpha_F(t-77)\right] \quad \text{or} \quad K_{t(°C)} = K_{25}\left[1 - \alpha_C(t-25)\right]$$

Table 29

DIELECTRIC CONSTANT AND DENSITY AT -4°F(-20°C), 77°F(25°C) AND 185°F(85°C)
GRADE 1100 NEW OILS

Specimen Number	Dielectric Constant at 400 cps			Density - Pounds per Gallon		
	-4°F(-20°C)	77°F(25°C)	185°F(85°C)	-4°F(-20°C)	77°F925°C)	185°F(85°C)
0-1-NR	2.313	2.262	2.194	7.615	7.380	7.053
*0-2-NR	2.281	2.234	2.162	7.594	7.345	7.018
0-3-NR	2.314	2.263	2.195	7.635	7.392	7.076
0-4-NR	2.311	2.260	2.192	7.627	7.390	7.067
0-6-NR	2.309	2.258	2.190	7.610	7.366	7.048
0-10-NR	2.295	2.245	2.177	7.582	7.349	7.017
0-14-NR	2.298	2.247	2.179	7.620	7.372	7.059
0-16-NR	2.289	2.239	2.171	7.569	7.326	7.002
*0-18-NR	2.268	2.221	2.157	7.553	7.316	7.005
0-20-NR	2.297	2.246	2.178	7.612	7.382	7.050
0-21-NR	2.267	2.217	2.150	7.573	7.334	7.007
*0-38-NA	2.307	2.234	2.176	7.606	7.356	7.035
0-45-NA	2.285	2.234	2.167	7.625	7.384	7.064
0-47-NA	2.303	2.252	2.184	7.605	7.361	7.042
0-68-NA	2.308	2.257	2.189	7.615	7.371	7.053

Table 30

DIELECTRIC CONSTANT AND DENSITY AT -4°F(-20°C), 77°F(25°C) AND 185°F(85°C)

Specimen Number	Grade	Dielectric Constant at 400 cps			Density - Pounds per Gallon		
		-4°F(-20°C)	77°F(25°C)	185°F(85°C)	-4°F(-20°C)	77°F(25°C)	185°F(85°C)
*0-11-NR	1080	2.296	2.246	2.180	7.587	7.336	7.008
*0-13-NR	1080	2.295	2.240	2.162	7.538	7.298	6.977
*0-36-NA	1080	2.324	2.263	2.228	7.614	7.365	7.053
0-52-NA	1080	2.301	2.252	2.187	7.598	7.354	7.034
0-67-NA	1080	2.386	2.336	2.268	7.538	7.292	6.968
*0-12-NR	1065	2.303	2.249	2.179	7.550	7.313	7.002
0-15-NR	1065	2.275	2.222	2.150	7.505	7.254	6.932
*0-33-NA	1065	2.300	2.237	2.172	7.558	7.311	6.984
0-48-NA	1065	2.289	2.235	2.163	7.538	7.298	6.968
0-69-NA	1065	2.297	2.243	2.171	7.547	7.305	6.978
0-7-NR	1010	2.225	2.176	2.111	7.467	7.215	6.889
*0-9-NR	1010	2.234	2.186	2.136	7.469	7.240	6.919
0-19-NR	1010	2.263	2.213	2.147	7.417	7.176	6.834
0-32-NA	1010	2.238	2.189	2.124	7.463	7.209	6.885
*0-34-NA	1010	2.244	2.200	2.127	7.454	7.205	6.884
*0-44-NA	1010	2.263	2.202	2.134	7.474	7.222	6.901
0-55-NR	1010	2.252	2.203	2.137	7.444	7.200	6.864
0-66-NA	1010	2.219	2.171	2.106	7.469	7.223	6.892
*0-8-NR	1005	2.176	2.139	2.072	7.327	7.074	6.730
*0-17-NR	1005	2.189	2.144	2.074	7.263	7.027	6.700
*0-41-NA	Hydraulic	2.342	2.256	2.172	7.375	7.118	6.776
0-46-NA	Hydraulic	2.334	2.260	2.162	7.381	7.128	6.794
0-53-NA	Hydraulic	2.259	2.188	2.093	7.431	7.188	6.850
*0-5-NR	1120	2.306	2.256	2.190	7.630	7.387	7.068

Table 31

CAPACITY INDEX AT -4°F(-20°C), 77°F(25°C), AND 185°F(85°C)
GRADE 1100 NEW OILS

Specimen Number	Capacity Index - (K-1)/D		
	-4°F(-20°C)	77°F(25°C)	185°F(85°C)
0-1-NR	.1724	.1710	.1693
*0-2-NR	.1687	.1680	.1656
0-3-NR	.1721	.1709	.1689
0-4-NR	.1719	.1705	.1687
0-6-NR	.1720	.1708	.1688
0-10-NR	.1708	.1694	.1677
0-14-NR	.1703	.1692	.1670
0-16-NR	.1703	.1691	.1672
*0-18-NR	.1679	.1669	.1652
0-20-NR	.1704	.1688	.1671
0-21-NR	.1673	.1659	.1641
*0-38-NA	.1718	.1678	.1672
0-45-NA	.1685	.1671	.1652
0-47-NA	.1713	.1701	.1681
0-68-NA	.1718	.1705	.1686

Table 32

CAPACITY INDEX AT -4°F(-20°C), 77°F(25°C), AND 185°F(85°C)

Specimen Number	Grade	Capacity Index - (K-1)/D		
		-4°F(-20°C)	77°F(25°C)	185°F(85°C)
*0-11-NR	1080	.1708	.1698	.1684
*0-13-NR	1080	.1718	.1699	.1665
*0-36-NA	1080	.1739	.1715	.1741
0-52-NA	1080	.1712	.1702	.1688
0-67-NA	1080	.1839	.1832	.1820
*0-12-NR	1065	.1726	.1708	.1684
0-15-NR	1065	.1699	.1685	.1659
*0-33-NA	1065	.1720	.1692	.1678
0-48-NA	1065	.1710	.1692	.1669
0-69-NA	1065	.1719	.1702	.1678
0-7-NR	1010	.1641	.1630	.1613
*0-9-NR	1010	.1652	.1638	.1642
0-19-NR	1010	.1703	.1690	.1678
0-32-NA	1010	.1659	.1649	.1633
*0-34-NA	1010	.1669	.1666	.1637
*0-44-NA	1010	.1690	.1664	.1643
0-55-NR	1010	.1682	.1671	.1656
0-66-NA	1010	.1632	.1621	.1605
*0-8-NR	1005	.1605	.1610	.1593
*0-17-NR	1005	.1637	.1628	.1603
*0-41-NA	Hydraulic	.1820	.1764	.1730
0-46-NA	Hydraulic	.1807	.1768	.1710
0-53-NA	Hydraulic	.1694	.1653	.1596
*0-5-NR	1120	.1712	.1700	.1684

Table 33

DIELECTRIC CONSTANT AT 400 CPS AND 200 KC, 185°F(85°C)

NR SPECIMENS

Specimen Number	Grade	Dielectric Constant at 400 Cps	Dielectric Constant at 200 KC
0-1-NR	1100	2.194	2.200
0-2-NR	1100	2.162	2.170
0-3-NR	1100	2.195	2.180
0-4-NR	1100	2.192	2.184
0-5-NR	1120	2.190	2.185
0-6-NR	1100	2.190	2.193
0-7-NR	1010	2.111	2.106
0-8-NR	1005	2.072	2.077
0-9-NR	1010	2.136	2.142
0-10-NR	1100	2.177	2.172
0-11-NR	1080	2.180	2.175
0-12-NR	1065	2.179	2.180
0-13-NR	1080	2.162	2.165
0-14-NR	1100	2.179	2.184
0-15-NR	1065	2.150	2.145
0-16-NR	1100	2.171	2.172
0-17-NR	1005	2.074	2.075
0-18-NR	1100	2.157	2.154
0-19-NR	1010	2.147	2.144
0-20-NR	1100	2.178	2.184
0-21-NR	1100	2.150	2.146
0-55-NR	1010	2.137	2.115

Table 34

DIELECTRIC CONSTANT AT 400 CPS AND 200 KC, 185°F(85°C)

NA SPECIMENS

Specimen Number	Grade	Dielectric Constant at 400 Cps	Dielectric Constant at 200 KC
0-32-NA	1010	2.124	2.115
0-33-NA	1065	2.172	2.173
0-34-NA	1010	2.127	2.120
0-36-NA	1080	2.228	2.224
0-38-NA	1100	2.176	2.171
0-41-NA	Hydraulic	2.172	2.167
0-44-NA	1010	2.134	2.133
0-45-NA	1100	2.167	2.156
0-46-NA	Hydraulic	2.162	2.165
0-47-NA	1100	2.184	2.193
0-48-NA	1065	2.163	2.158
0-52-NA	1080	2.187	2.197
0-53-NA	Hydraulic	2.093	2.085
0-66-NA	1010	2.106	2.087
0-67-NA	1080	2.268	2.261
0-68-NA	1100	2.189	2.188
0-69-NA	1065	2.171	2.166

Table 35

DIELECTRIC CONSTANT AT 400 CPS AND 200 KC, 185°F(85°C)

UA SPECIMENS

Specimen Number	Grade	Dielectric Constant at 400 Cps	Dielectric Constant at 200 KC
0-35-UA	1010	2.305	2.295
0-37-UA	1080	2.256	2.247
0-39-UA	1100	2.266	2.260
0-40-UA	Hydraulic	2.184	2.184
0-49-UA	1100	2.234	2.225
0-50-UA	Hydraulic	2.178	2.170
0-51-UA	1065	2.173	2.181
0-54-UA	1065	2.166	2.159
0-70-UA	1010	2.053	2.051
0-71-UA	1080	2.202	2.189
0-72-UA	1100	2.259	2.246
0-73-UA	Hydraulic	2.006	2.005

Table 36

DIELECTRIC CONSTANT AT 400 CPS AND 200 KC, 185°F(85°C)

UB SPECIMENS

Specimen Number	MLO No.	Dielectric Constant at 400 Cps	Dielectric Constant at 200 KC
0-22-UB	MLO-5319	2.103	2.111
0-23-UB	MLO-5320	2.112	2.117
0-24-UB	MLO-5321	2.209	2.213
0-25-UB	MLO-5322	2.199	2.208
0-26-UB	MLO-5323	2.269	2.265
0-27-UB	MLO-5324	2.250	2.232
0-28-UB	MLO-5325	2.252	2.249
0-29-UB	MLO-5326	2.242	2.232
0-30-UB	MLO-5327	2.218	2.209
0-31-UB	MLO-5328	2.221	2.213
0-42-UB	MLO-5581	2.183	2.169
0-43-UB	MLO-5582	2.218	2.211
0-77-UB	MLO-6018	2.141	2.132
0-78-UB	MLO-6019	2.142	2.128
0-79-UB	MLO-6020	2.262	2.257
0-80-UB	MLO-6021	2.220	2.223
0-81-UB	MLO-6022	2.255	2.246
0-82-UB	MLO-6023	2.261	2.257
0-83-UB	MLO-6024	2.247	2.239
0-84-UB	MLO-6025	2.253	2.247

Table 37

DIELECTRIC CONSTANT AT 185°F(85°C)

NEW OIL SPECIMENS FROM REFINERIES

Specimen Number	Grade	Frequency							
		400 CPS	1 KC	5 KC	10 KC	20 KC	50 KC	100 KC	200 KC
0-8-NR	1005	2.072	2.078	2.076	2.079	2.081	2.080	2.079	2.077
0-11-NR	1080	2.180	2.180	2.181	2.179	2.174	2.176	2.177	2.175
0-15-NR	1065	2.150	2.151	2.152	2.150	2.148	2.148	2.147	2.145
0-20-NR	1100	2.178	2.178	2.180	2.181	2.180	2.179	2.182	2.184
0-55-NR	1010	2.137	2.134	2.146	2.141	2.143	2.142	2.139	2.115

Table 38

DIELECTRIC CONSTANT AT 185°F(85°C)

NEW OIL SPECIMENS FROM AIR FORCE BASES

Specimen Number	Grade	Frequency							
		400 CPS	1 KC	5 KC	10 KC	20 KC	50 KC	100 KC	200 KC
0-53-NA	Hydraulic	2.093	2.088	2.085	2.088	2.090	2.087	2.085	2.085
0-66-NA	1010	2.106	2.097	2.103	2.103	2.111	2.103	2.094	2.087
0-67-NA	1080	2.268	2.265	2.265	2.265	2.275	2.265	2.263	2.261
0-68-NA	1100	2.189	2.187	2.186	2.186	2.195	2.193	2.195	2.188
0-69-NA	1065	2.171	2.168	2.168	2.166	2.176	2.175	2.168	2.166

Table 39

DIELECTRIC CONSTANT AT 185°F(85°C)

USED OIL SPECIMENS FROM AIR FORCE BASES

Specimen Number	Grade	Frequency							
		400 CPS	1 KC	5 KC	10 KC	20 KC	50 KC	100 KC	200 KC
0-39-UA	1100	2.266	2.263	2.264	2.258	2.262	2.269	2.265	2.260
0-54-UA	1065	2.166	2.166	2.162	2.161	2.174	2.168	2.161	2.159
0-70-UA	1010	2.053	2.054	2.050	2.061	2.064	2.057	2.055	2.051
0-71-UA	1080	2.202	2.201	2.199	2.197	2.206	2.194	2.189	2.189

Table 40

DIELECTRIC CONSTANT AT 185°F(85°C)

USED OIL SPECIMENS DIRECT FROM BOMBERS

Specimen Number	MLO-No.	Frequency							
		400 CPS	1 KC	5 KC	10 KC	20 KC	50 KC	100 KC	200 KC
0-22-UB	MLO-5319	2.103	2.102	2.100	2.102	2.103	2.108	2.112	2.111
0-23-UB	MLO-5320	2.112	2.113	2.108	2.108	2.114	2.119	2.119	2.117
0-24-UB	MLO-5321	2.209	2.208	2.208	2.208	2.204	2.209	2.218	2.213
0-25-UB	MLO-5322	2.199	2.196	2.203	2.193	2.196	2.210	2.209	2.208
0-26-UB	MLO-5323	2.269	2.269	2.275	2.256	2.260	2.275	2.266	2.265
0-27-UB	MLO-5324	2.250	2.245	2.250	2.234	2.237	2.246	2.237	2.232
0-43-UB	MLO-5582	2.218	2.216	2.209	2.209	2.212	2.218	2.209	2.211

Table 41

DIELECTRIC CONSTANT, DENSITY, CAPACITY INDEX, AND DISSIPATION FACTOR AT 77°F(25°C) AND 400 CPS
10% DILUTED SPECIMENS

Specimen Number	Grade	Dielectric Constant	Density Lb/Gallon	Capacity Index (K-1)/D	Dissipation Factor
0-1-10D	1100	2.230	7.233	.1701	—
0-2-10D	1100	2.233	7.197	.1713	—
0-3-10D	1100	2.246	7.237	.1722	—
0-4-10D	1100	2.232	7.233	.1703	—
0-5-10D	1120	2.224	7.276	.1682	—
0-6-10D	1100	2.234	7.200	.1714	—
0-7-10D	1010	2.169	7.082	.1650	.0034
0-8-10D	1005	2.130	6.960	.1624	.0008
0-9-10D	1010	2.173	7.073	.1658	.0100
0-10-10D	1100	2.218	7.200	.1692	—
0-11-10D	1080	2.223	7.193	.1700	—
0-12-10D	1065	2.194	7.166	.1666	—
0-13-10D	1080	2.201	7.149	.1680	—
0-14-10D	1100	2.216	7.220	.1684	—
0-15-10D	1065	2.201	7.127	.1685	—
0-16-10D	1100	2.208	7.186	.1681	—
0-17-10D	1005	2.120	6.885	.1627	—
0-18-10D	1100	2.201	7.180	.1673	—
0-19-10D	1010	2.163	7.032	.1654	—
0-20-10D	1100	2.224	7.229	.1693	—
0-21-10D	1100	2.194	7.192	.1660	—

Table 42

DIELECTRIC CONSTANT, DENSITY, CAPACITY INDEX, AND DISSIPATION FACTOR AT 77°F(25°C) AND 400 CPS

20% DILUTED SPECIMENS

Specimen Number	Grade	Dielectric Constant	Density Lb/Gallon	Capacity Index (K-1)/D	Dissipation Factor
0-1-20D	1100	2.185	7.074	.1675	—
0-2-20D	1100	2.193	7.041	.1694	—
0-3-20D	1100	2.203	7.076	.1700	—
0-4-20D	1100	2.199	7.079	.1694	.0008
0-5-20D	1120	2.178	7.084	.1663	—
0-6-20D	1100	2.197	7.064	.1695	—
0-7-20D	1010	2.143	6.987	.1636	.0054
0-8-20D	1005	2.100	6.802	.1617	—
0-9-20D	1010	2.142	6.936	.1646	.0104
0-10-20D	1100	2.148	7.048	.1629	—
0-11-20D	1080	2.176	7.037	.1671	—
0-12-20D	1065	2.176	7.000	.1680	—
0-13-20D	1080	2.179	7.013	.1681	—
0-14-20D	1100	2.220	7.211	.1692	—
0-15-20D	1065	2.148	6.963	.1649	—
0-16-20D	1100	2.167	7.033	.1659	—
0-17-20D	1005	2.107	6.800	.1628	—
0-18-20D	1100	2.163	7.033	.1654	—
0-19-20D	1010	2.137	6.896	.1649	—
0-20-20D	1100	2.206	7.069	.1706	—
0-21-20D	1100	2.161	7.024	.1653	—

Table 43

DIELECTRIC CONSTANT, DENSITY, CAPACITY INDEX, AND DISSIPATION FACTOR AT 77°F(25°C) AND 400 CPS

30% DILUTED SPECIMENS

Specimen Number	Grade	Dielectric Constant	Density Lb/Gallon	Capacity Index (K-1)/D	Dissipation Factor
0-1-30D	1100	2.173	6.919	.1695	---
0-2-30D	1100	2.164	6.919	.1682	.0008
0-3-30D	1100	2.174	6.922	.1696	---
0-4-30D	1100	2.167	6.968	.1675	.0012
0-5-30D	1120	2.178	6.933	.1699	---
0-6-30D	1100	2.165	6.914	.1685	---
0-7-30D	1010	2.109	6.812	.1628	.0027
0-8-30D	1005	2.097	6.698	.1638	.0011
0-9-30D	1010	2.132	6.829	.1658	.0183
0-10-30D	1100	2.147	6.911	.1660	---
0-11-30D	1080	2.175	6.910	.1700	---
0-12-30D	1065	2.168	6.864	.1702	---
0-13-30D	1080	2.145	6.907	.1658	.0026
0-14-30D	1100	2.164	6.922	.1682	---
0-15-30D	1065	2.146	6.837	.1676	---
0-16-30D	1100	2.130	6.892	.1640	---
0-17-30D	1005	2.087	6.671	.1629	.0008
0-18-30D	1100	2.159	6.916	.1676	---
0-19-30D	1010	2.129	6.790	.1663	---
0-20-30D	1100	2.189	6.947	.1712	---
0-21-30D	1100	2.144	6.902	.1657	---

Table 44

MEAN VALUES AT 400 CPS AND 77°F(25°C)

NEW OILS FROM REFINERIES

Grade	Number of Specimens	Mean Dielectric Constant	Mean Density	Mean Capacity Index
1100	11	2.245	7.359	.1691
1080	2	2.243	7.317	.1699
1065	2	2.236	7.284	.1697
1010	3	2.192	7.210	.1653
1005	2	2.142	7.051	.1619
1120	1	2.256	7.387	.1700

Table 45

MEAN VALUES AT 400 CPS AND 77°F(25°C)
(10% DILUTED NEW OILS)

Grade	Number of Specimens	Mean Dielectric Constant	Mean Density	Mean Capacity Index
1100	11	2.221	7.210	.1694
1080	2	2.212	7.171	.1690
1065	2	2.198	7.147	.1676
1010	3	2.168	7.062	.1654
1005	2	2.125	6.923	.1626
1120	1	2.224	7.276	.1682

Table 46

MEAN VALUES AT 400 CPS AND 77°F(25°C)
(20% DILUTED NEW OILS)

Grade	Number of Specimens	Mean Dielectric Constant	Mean Density	Mean Capacity Index
1100	11	2.186	7.068	.1677
1080	2	2.178	7.025	.1676
1065	2	2.162	6.982	.1665
1010	3	2.141	6.940	.1644
1005	2	2.104	6.801	.1623
1120	1	2.178	7.084	.1663

Table 47

MEAN VALUES AT 400 CPS AND 77°F(25°C)
(30% DILUTED NEW OILS)

Grade	Number of Specimens	Mean Dielectric Constant	Mean Density	Mean Capacity Index
1100	11	2.161	6.921	.1678
1080	2	2.160	6.909	.1679
1065	2	2.157	6.851	.1689
1010	3	2.123	6.810	.1650
1005	2	2.092	6.685	.1634
1120	1	2.178	6.933	.1699

Table 48

DIELECTRIC CONSTANT AT 400 CPS AND 200 KC, 77°F(25°C)

10% DILUTED SPECIMENS

Specimen Number	Grade	Dielectric Constant at 400 CPS	Dielectric Constant at 200 KC
0-1-10D	1100	2.230	2.238
0-2-10D	1100	2.233	2.239
0-3-10D	1100	2.246	2.237
0-4-10D	1100	2.232	2.232
0-5-10D	1120	2.224	2.220
0-6-10D	1100	2.234	2.239
0-7-10D	1010	2.169	2.169
0-8-10D	1005	2.130	2.137
0-9-10D	1010	2.173	2.165
0-10-10D	1100	2.218	2.224
0-11-10D	1080	2.223	2.220
0-12-10D	1065	2.194	2.202
0-13-10D	1080	2.201	2.203
0-14-10D	1100	2.216	2.211
0-15-10D	1065	2.201	2.195
0-16-10D	1100	2.208	2.212
0-17-10D	1005	2.120	2.121
0-18-10D	1100	2.201	2.206
0-19-10D	1010	2.163	2.160
0-20-10D	1100	2.224	2.228
0-21-10D	1100	2.194	2.188

Table 49

DIELECTRIC CONSTANT AT 400 CPS AND 200 KC, 77°F(25°C)

20% DILUTED SPECIMENS

Specimen Number	Grade	Dielectric Constant at 400 CPS	Dielectric Constant at 200 KC
0-1-20D	1100	2.185	2.190
0-2-20D	1100	2.193	2.188
0-3-20D	1100	2.203	2.194
0-4-20D	1100	2.199	2.189
0-5-20D	1120	2.178	2.174
0-6-20D	1100	2.197	2.189
0-7-20D	1010	2.143	2.138
0-8-20D	1005	2.100	2.102
0-9-20D	1010	2.142	2.136
0-10-20D	1100	2.148	2.154
0-11-20D	1080	2.176	2.173
0-12-20D	1065	2.176	2.178
0-13-20D	1080	2.179	2.172
0-14-20D	1100	2.220	2.216
0-15-20D	1065	2.148	2.158
0-16-20D	1100	2.167	2.158
0-17-20D	1005	2.107	2.109
0-18-20D	1100	2.163	2.167
0-19-20D	1010	2.137	2.144
0-20-20D	1100	2.206	2.213
0-21-20D	1100	2.161	2.152

Table 50

DIELECTRIC CONSTANT AT 400 CPS AND 200 KC, 77°F(25°C)

30% DILUTED SPECIMENS

Specimen Number	Grade	Dielectric Constant at 400 CPS	Dielectric Constant at 200 KC
0-1-30D	1100	2.173	2.163
0-2-30D	1100	2.164	2.171
0-3-30D	1100	2.174	2.181
0-4-30D	1100	2.167	2.173
0-5-30D	1120	2.178	2.178
0-6-30D	1100	2.165	2.162
0-7-30D	1010	2.109	2.115
0-8-30D	1005	2.097	2.102
0-9-30D	1010	2.132	2.138
0-10-30D	1100	2.147	2.161
0-11-30D	1080	2.175	2.178
0-12-30D	1065	2.168	2.162
0-13-30D	1080	2.145	2.148
0-14-30D	1100	2.164	2.171
0-15-30D	1065	2.146	2.135
0-16-30D	1100	2.130	2.134
0-17-30D	1005	2.087	2.084
0-18-30D	1100	2.159	2.168
0-19-30D	1010	2.129	2.121
0-20-30D	1100	2.189	2.189
0-21-30D	1100	2.144	2.146

Table 51

DIELECTRIC CONSTANT AT 77°F(25°C)

Specimen Number	Grade	Frequency							
		400 CPS	1 KC	5 KC	10 KC	20 KC	50 KC	100 KC	200 KC
0-2-10D	1100	2.239	2.239	2.239	2.239	2.241	2.239	2.239	2.239
0-7-10D	1010	2.169	2.168	2.174	2.171	2.169	2.168	2.168	2.169
0-8-10D	1005	2.130	2.127	2.134	2.134	2.132	2.130	2.135	2.137
0-11-10D	1080	2.223	2.218	2.218	2.223	2.220	2.218	2.218	2.220
0-15-10D	1065	2.201	2.201	2.199	2.201	2.198	2.196	2.196	2.195
0-16-10D	1100	2.208	2.210	2.207	2.208	2.205	2.207	2.212	2.212

Table 52

DIELECTRIC CONSTANT AT 77°F(25°C)

Specimen Number	Grade	Frequency 400 Cps	1 KC	5 KC	10 KC	20 KC	50 KC	100 KC	200 KC
0-5-30D	1120	2.178	2.175	2.182	2.182	2.183	2.187	2.178	2.178
0-9-30D	1010	2.132	2.133	2.138	2.143	2.133	2.139	2.132	2.138
0-1-30D	1100	2.173	-	-	-	2.172	-	2.166	2.163
0-11-30D	1080	2.160	-	-	-	2.158	-	2.162	2.160
0-15-30D	1065	2.146	-	-	-	2.147	-	2.141	2.135
0-19-30D	1010	2.129	-	-	-	2.124	-	2.126	2.121
0-6-20D	1100	2.197	-	-	-	2.196	-	2.197	2.189
0-7-20D	1010	2.143	-	-	-	2.148	-	2.146	2.138

Table 53

EFFECT OF ADDITIVES

Specimen Number	Materials Laboratory Number	Identification	Percent of Compound Blended with Base Grade 1100 Oil	Dielectric Constant 400 Cps-77°F(25°C)	Density at 77°F(25°C) Lbs/Gallon	Capacity Index (K-1) /D	Dissipation Factor at 400 Cps
0-65S	——	Base Oil	——	2.253	7.363	.1702	.0018
0-56-S	MLM-5311	RP Petronate 50	5% by wt.	2.305	7.365	.1772	.0289
0-57-S	MLM-5312	Petronate HL	5% by wt.	2.346	7.364	.1828	.0317
0-58-S	MLM-5313	Acryloid 50	1% by vol.	2.217	7.322	.1662	.0082
0-59-S	MLM-5314	Additive	20% by wt.	2.493	7.488	.1994	.2450
0-60-S	MLM-5315	Paraflow PDX	1% by vol.	2.218	7.313	.1666	.0017
0-61-S	MLM-5318	Santopour "B"	1% by vol.	2.251	7.318	.1709	——
0-62-S	MLM-5442	Lubrizol 701	0.75% by wt.	2.263	7.325	.1724	——
0-63-S	MLM-5443	Additive 895-41	15% by wt.	2.243	7.316	.1699	——
0-64-S	MLM-5439 MLM-5440 MLM-5446 MLM-5441	Additive 118 Perma 22 Ionol Additive 171	0.011 by wt. 0.25 " 1.0 " 0.97 "	2.176	7.321	.1606	——

Table 54

DIELECTRIC CONSTANT AT 400 CPS AND 200 KC, 77°F(25°C)

EFFECT OF ADDITIVE SAMPLES

Specimen Number	Identification	Dielectric Constant at 400 Cps	Dielectric Constant at 200 KC
0-65-S	Base Oil	2.253	2.243
0-56-S	RP Petronate 50	2.305	2.294
0-57-S	Petronate HL	2.346	2.329
0-58-S	Acryloid 150	2.217	2.209
0-59-S	Additive	2.493	2.501
0-60-S	Paraflow PDX	2.218	2.205
0-61-S	Santopour "B"	2.251	2.251
0-62-S	Lubrizol 701	2.263	2.268
0-63-S	Additive 895-41	2.243	2.237
0-64-S	Additive 118 Perma 22 Ionol Additive 171	2.176	2.166

Table 55

DIELECTRIC CONSTANT AT 77°F(25°C)

EFFECT OF ADDITIVE SPECIMENS

Specimen Number	Identification	Frequency							
		400 CPS	1 KC	5 KC	10 KC	20 KC	50 KC	100 KC	200 KC
0-61-S	MLM-5318	2.251	2.248	2.256	2.253	2.244	2.248	2.251	2.251
0-62-S	MLM-5442	2.263	2.263	2.253	2.265	2.257	2.264	2.268	2.268
0-63-S	MLM-5443	2.243	2.243	2.245	2.243	2.240	2.244	2.244	2.237
0-64-S	MLM-5439 MLM-5440 MLM-5446 MLM-5441	2.176	2.171	2.169	2.169	2.165	2.176	2.173	2.166

Table 56

DIELECTRIC CONSTANT AT 400 CYCLES PER SECOND
DENSITY IN AIR (LB/GALLON), AND CAPACITY INDEX
EFFECT OF ADDITIVE SPECIMENS

Specimen Number	Identification		Temperature, Degrees F 10°F(-10°C)	77°F(25°C)	185°F(85°C)
0-65-S	Base Oil	(DC)	2.293	2.253	2.183
		(D)	7.560	7.363	7.040
		(CI)	.1710	.1702	.1680
0-56-S	RP Petronate 50	(DC)	2.346	2.305	2.231
		(D)	7.566	7.365	7.045
		(CI)	.1779	.1772	.1747
0-57-S	Petronate HL	(DC)	2.392	2.346	2.276
		(D)	7.560	7.364	7.039
		(CI)	.1842	.1828	.1813
0-58-S	Acryloid 50	(DC)	2.258	2.217	2.146
		(D)	7.523	7.322	6.998
		(CI)	.1672	.1662	.1638
0-59-S	Additive	(DC)	2.526	2.493	2.405
		(D)	7.683	7.488	7.174
		(CI)	.1986	.1994	.1958
0-60-S	Paraflow PDX	(DC)	2.258	2.218	2.149
		(D)	7.514	7.313	6.988
		(CI)	.1674	.1666	.1644

Table 57

DISSIPATION FACTOR AT 400 CYCLES PER SECOND

EFFECT OF ADDITIVE SPECIMENS

Specimen Number	Identification	Dissipation Factor at 400 Cycles Per Second		
		10°F(-10°C)	77°F(25°C)	185°F(85°C)
0-65-S	Base Oil	.0007	.0018	.0082
0-56-S	RP Petronate 50	.0033	.0289	.7920
0-57-S	Petronate HL	.0037	.0317	.9212
0-58-S	Acryloid 50	.0012	.0082	.1782
0-59-S	Additive	.0372	.2450	5.2700
0-60-S	Paraflow PDX	---	.0017	.0193